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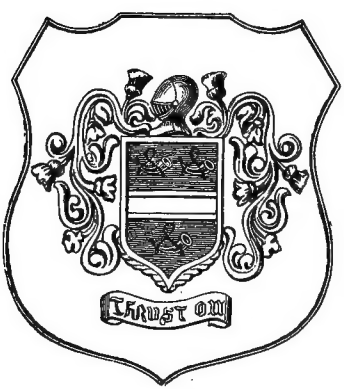

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TIMBER

AND TIMBER TREES.

TIMBER

AND TIMBER TREES,

NATIVE AND FOREIGN.

BY

THOMAS LASLETT,

TIMBER INSPECTOR TO THE ADMIRALTY.

London:
MACMILLAN AND CO.
1875.

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TO

THE RT. HONBLE. G. WARD HUNT, M.P.,

FIRST LORD OF THE ADMIRALTY,

AS A MARK OF RESPECT, BY HIS VERY OBEDIENT SERVANT,

THOMAS LASLETT.

PREFACE.

A HANDY-BOOK on Home and Foreign Timber, for ship and house building purposes, is, in the opinion of many, much required. The botanical treatises which are accessible are too strictly scientific in their form and treatment to interest the general reader, and they lack that practical application of knowledge to the wants of the shipwright and carpenter, which it is one of the aims of this book to give. Hence, I have endeavoured to concentrate into one form all the information which books and long experience could give, and so to arrange the materials as to make them intelligible and acceptable alike to the master builder and apprentice.

Keeping this in view, I have introduced into the work the substance of a course of lectures on the properties of timber, which I delivered at the Royal School of Naval Architecture at South Kensington;

and of three other courses of lectures on the same subject, delivered at the Royal School of Military Engineering at Brompton Barracks, Chatham.

Many new descriptions are treated of, and a great number of experiments on the strength of timber are given in detail as well as in the abstract. Further, there are some useful notes on seasoning timber for use, and the best means to be taken for its preservation.

THOMAS LASLETT.

58, MARYON ROAD, CHARLTON, S.E.
September, 1875.

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TIMBER

AND TIMBER TREES.

INTRODUCTION.

THE properties and characteristic qualities of the timber available for works of construction are so numerous and important, and yet so little understood generally, that I am induced by the solicitations of many friends to give, in these pages, all the information respecting them which I have been able to collect. This collection has been made during a long course of practice in the working of forests, and in the employment of a great variety of woods, and I am not without hope that the results will be of service to many who are engaged in carpentry, shipbuilding, and engineering.

To the students of these branches of art, it will be my aim to make the work especially useful, as I propose to treat, not only of the timber known to, and dealt with in commerce, but to extend my observations to a few others which, for the most part, are equally valuable, although, at present, they are scarcely known beyond the localities in which they grow. I propose also to treat of the defects most frequently met with in timber,

and of the influences they severally exert on the strength and durability of the pieces in which they occur; and, further, to offer a few remarks on the principal points that should be attended to in selecting timber for use.

It will also be in keeping with the object in view, if I treat of the growth and formation of timber trees; a slight knowledge, at least, of this being necessary to enable us to appreciate their character and general capabilities.

CHAPTER I.

ON THE GROWTH AND STRUCTURE OF TREES.

THE stems of Exogenous* trees may be described as of one uniform structure and mode of increase, and are usually very firm, yielding the most solid and best description of timber, their solidity and strength fitting them admirably for use in carpentry, and for many domestic purposes.

The most common form of stem is the cylindrical, but it is occasionally found grooved or fluted, and not unfrequently flattened, approximating to an oval; the cylindrical form being, for most purposes, the best for conversion into beams, joists, boards, &c.

Botanists speak of the stem as the "ascending axis" of a tree, from its taking an upward direction and giving off branches. In the Elm, these branches take an oblique upward direction; in the Birch, they are also oblique, slightly pendulous, and flexible; those of the Willow are somewhat oblique, with the lateral branchlets pendulous and drooping in graceful curves; in the

---

* Exogens are a vegetable class, which augment their woody matter by additions to the outside of that which is first formed; as long, therefore, as they grow a new layer of wood is added to the outside of the previous growth. The Endogen class—*i.e.*, Palms, &c. &c.—differ from the above, in having their substance formed by successive additions from the inside.

Poplar and Cypress they are nearly erect; the Oak, in open and exposed situations, taking a wide-spreading form, its branches assuming every imaginable curve; while in the Cedar they are nearly at a right angle.

The stem is constructed upon the principle of a cone, and consists of a series of perfected layers designated heart-wood, or duramen, with, commonly outside these, some layers that are imperfect, which are known as the sap-wood, or alburnum; while the exterior is composed of the bark, or liber. The main portion of the stem is broadest at the base, and somewhat bell-shaped near the root, but gradually diminishes upwards to the part where the first branches are thrown out, and from this point there is again a still further diminution, until it is finally lost in the extremity of the branchlets.

The central and first-formed part of an exogenous stem, namely, the pith, is composed of cellular tissues, the cells being very numerous and varying considerably in size, but generally diminishing towards the outer edge. The pith is somewhat large and full of fluid in the young plant, but does not increase in bulk as the tree grows older; on the contrary, it appears rather to diminish than otherwise, by the fluid drying out. It retains, however, its place in the oldest trees, in the form of a dry consistent powder, although it is scarcely noticeable in some species on their arrival at maturity.

In the employment of timber in carpentry, due regard must always be had to the position of the pith, since there is an outside and an inside to every board and piece of scantling; and the careful workman is so well aware of this, that he will study to leave, if possible, in any work of construction, the outer side only exposed. It is, therefore, necessary in every case to

look for the pith or centre of the stem, or—if that has been removed by the conversion of the tree—for the innermost, or oldest layer of heart-wood, in the plank or board, as that will be the inside of it. If this precaution is disregarded, the innermost or

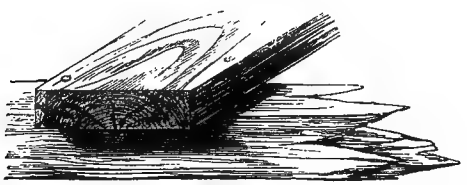

FIG. 1.

earlier layers of wood lift and shell out, after exposure for a time, in shreds and strips, the cohesive properties of the ligneous layers having been destroyed by the action of the atmosphere. Fig. 1 shows the plank properly fixed, with the inner or earlier layers of wood

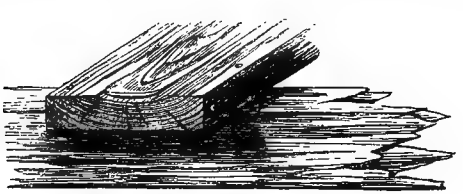

FIG. 2.

against the beam, in which position it is impossible for them to separate. Fig. 2 shows the plank improperly fixed, with the outer, or later layers of wood against the beam, in which position the earlier layers are very liable to lift, or shell out, destroying the evenness of surface;

and when so used in decks, flooring, &c., rendering it dangerous to walk upon.

In the transverse section of a tree will be found a number of lines radiating from the centre and presenting a star-like appearance. These are the medullary rays of the botanists, but are best known to carpenters as the silver grain, or felt (*a*, Fig. 3). This peculiarity of appearance is due to thin plates of compressed cellular tissues, which usually run continuously from the pith to the bark. Although, as a general rule, this is the case, yet in some species a secondary series is found, overlapping or scarfing by, but very seldom touching, the primary rays (*b*, Fig. 3). If, therefore, we carefully examine the smooth surface of a transverse section of the stems of most trees, we can generally trace these thin plates or rays. They can be seen to great advantage in the Beech, and, more or less, in all the varieties of Oak; but they are far less distinct in the Lime, Yew, and Chestnut, and in the Firs and Pines they cannot be traced, although botanists believe them to be present.

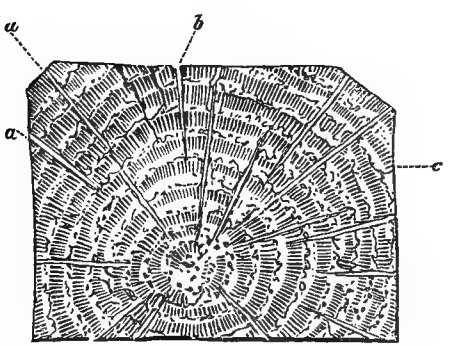

FIG. 3.

Before converting or employing most kinds of woods, particularly in dealing with unseasoned timber, it will be

necessary, for many purposes in carpentry, to regard this arrangement of medullary rays, to insure that the work shall remain, when finished, free from warp or twist upon the surface. The timber should be cut as nearly as possible in the direction of these rays, the shrinkage in seasoning being, for the most part, angular to them. Workmen in general, and modellers in wood in particular, endeavour to embrace the greatest length of medullary figure in their work to guard against warping, well knowing that if they do so it will stand satisfactorily the test of time and wear. Others, who are engaged in the cleaving of posts, rails, or palings for park and other fences, know that they can only successfully do this by rending the piece in the direction of these rays. It is by a careful study of this that we obtain our best and most beautifully figured wainscot from the slow-growing Oaks found in the North of Europe, Austria, Asia Minor, and in some districts of North America.

By the contact of these medullary rays with the annual layers, and chiefly in the newly-formed wood, a means is afforded for the ascent of sap from the root. The sap is believed to be drawn upwards every spring by capillary attraction, and continues for a time to flow through the pores and fibres of the tree until it reaches the upper side of the leaves; thence it returns, by the under side of the leaf downwards, between the outer circle or zone of ligneous layers and the bark, permeating in its course the whole body of the tree, and contributing to form annually a new layer. During this progress the sap undergoes some very important chemical change, and, becoming gradually elaborated, tends to the formation of a substance called cambium, between the liber, or bark, and the alburnum. The stem is thus enlarged by a new layer on the outside of

the alburnum, while a portion of the sap being absorbed by the bark increases its elasticity and assists the development by the addition of a new layer on the inside.

Thus the bark of trees is expansive in character, and this accounts for the differences observable on the surface, which varies from great smoothness, as in the Beech, to extreme ruggedness in the Chestnut, and to strips and flakes in some other kinds.

It is upon the pith and its sheath that the first year's growth of lignine, or woody matter, is formed, and the whole structure of the stem raised. The several concentric rings or layers which surround, and are, as it were, moulded upon it to form the cone, are generally well formed and uniform in thickness, seldom varying except when the pith is excentrically placed, or deviates somewhat from the centre. Whenever this is the case, the thinner layers will be found upon the side having the smallest semi-diameter; while on the reverse side, owing to the annual supply of ligneous matter having been drawn in that direction by atmospheric influences, they are found to be compensatingly thicker, but are a little less dense in texture.

The yearly growth or increase is thus defined by concentric circles outside the medullary sheath (*c*, Fig. 3). These are generally clear to common observation in a transverse section of a stem, the outer portion of each being of a firm and dense texture, while the inner part is perceptibly vascular and more or less porous; the quality of the wood, and its fitness for architectural or engineering purposes, depending, to a great extent, upon the degree of firmness and solidity of the annual layers. These are all very plainly marked in the Oak and Fir, and in most woods; but in the Maple and Lime, and in some others, as also in many trees of tropical growth,

they are not nearly so distinct; indeed, in some it is impossible to trace them.

The woody layers, when first formed, are full of sap, but they change and gradually become solidified by the compression of each subsequent layer; and it seems obvious, that as each zone is moulded upon the one of the previous year's growth, it would, by cohesion, become amalgamated with it. The perfecting of the concentric layer is, however, a very gradual process,

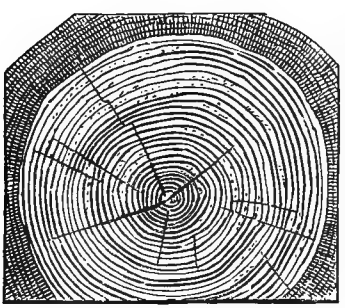

FIG. 4.

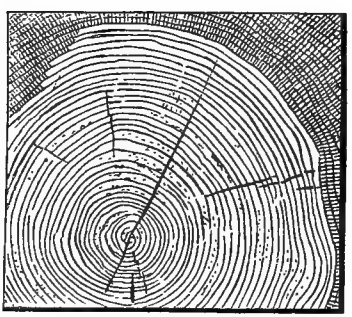

FIG. 5.

and the time necessary to convert a new layer of sap-wood into heart-wood (which alone represents the serviceable timber in most trees) varies from about one year, as in Hornbeam, Ash, Beech, and in some other species, to thirty years or even more, as in Oak, &c. &c. It seems, as a rule, from evidence to be shown later on ~~in Table~~ II., that Oak trees which form their wood most rapidly under ordinary conditions of growth are the best in quality. In the Firs it is the same, and we see it also in the Pines (Kauri excepted). I incline, therefore, to the opinion that it must be the case in every

description of timber, and that such trees are not only the best, but the most durable.

Under ordinary conditions of growth, and with most trees, the conversion or change of the alburnum into duramen takes place with great regularity (Fig. 4); but to this rule there are exceptions in every species, a variety of influences, such as temperature, aspect, soil, and others less understood, apparently bearing upon and tending to disturb this regularity. It is, indeed, often found that outside the completed circles of duramen, portions of the circumference of several successive layers of alburnum (Fig. 5) have already been changed into heart-wood, while the rest remain to be indurated in the ordinary course; the perfected segments generally occurring earlier on the south side of trees of the Northern Hemisphere, and on the north side of those of the Southern Hemisphere.

This is, perhaps, only to be accounted for by the supposition that, being exposed to the most powerful rays of the sun, especially during the summer months, the principal strength of the indurating elements of the sap is drawn to that particular side; while, on the reverse side, the action is much slower, owing to the partially exhausted state of the juices and the deadening effects of cold.

This hypothesis is supported by the fact that, in the Firs and Pines, we frequently find patches of indurated wood, somewhat darker in colour than the rest, and brittle in character. The brittleness is easily accounted for by supposing the first strength of the sap to have been drawn to the other side of the tree, and the conversion of these portions of sap-wood into heart-wood to have been much slower than would have been the case had the action of the sap been uniform.

Such indurations of portions of the layers occur more frequently in the Firs and Pines than in the wood of trees of harder and more compact texture. In Dantzic Fir, for example, I have noticed parts of twenty or more concentric rings changed from alburnum into duramen, or heart-wood, while the remaining portions of the circles retained their sap-like or alburnum character, and greater or less deviations in this respect are frequently met with in other species. It may be that these can only be accounted for by the exceptional influences before mentioned, for it seems quite possible that, whenever a tree is suddenly thrown open and exposed by the clearing away of others from its vicinity, the hardening process will go on with unusual rapidity.

In such Firs and Pines as have been sheltered in the depths of a forest, we do not find the wood of this variable character, as the perfecting of the duramen takes place then with much greater regularity and uniformity, if somewhat less rapidly, than in more exposed situations.

This peculiarity of growth is more strikingly exemplified in the Firs and Pines, and occurs with greater frequency in trees of this kind than in any others. Accidental circumstances no doubt affect the sap-wood of many other kinds to a greater or less degree; but in trees of a close texture the want of vigour in the sap is generally found to affect the whole circumference of a layer rather than several distinct portions of it.

The proportion of sap-wood, or alburnum, to heart-wood, or duramen, in trees in which it occurs, is excessive in the young, but decreases rapidly as they advance in age, the difference being in some measure attributable to the fact that, as the circumference of the tree increases, the tissues of each successive layer, or annual ring, are

spread over a larger surface. The sap-wood is, as a rule, darker in the white-wood class than the heart-wood, whether seasoned or unseasoned, but is paler in colour in most hardwood trees which have had time to season. In some of the white, or softer woods, when fresh cut, the difference is scarcely perceptible; but exposure to the air quickly gives to the outer layers a greenish tinge, as a species of mildew attacks them. With, I believe, only a few solitary exceptions, great care is taken to remove all sap-wood from the scantlings under conversion, if they are required for works of an important character.

CHAPTER II.

ON THE GROWTH AND STRUCTURE OF TREES (*Continued*).

MOST writers upon the subject of the growth of timber are agreed in ascribing the hardening of the inner layers of the wood to the indurating action of the juices upon the fibres and on the tissues, and thus far I have treated of the process as carried on solely by this means; but another and a very different force is thought to be simultaneously exerted, which must at least accelerate the change we have referred to. It will be remembered that each year the sap, collecting between the last-formed ring and the bark, congeals there, and forms a new layer. This layer, as it solidifies, appears to exert a double influence upon the tree, inasmuch as it exercises an expansive force upon the bark, thereby causing it gradually to yield, while the resistance it offers, slight though it may be, acts as a compressive force upon the whole of the tree comprised within the circumference of the new layer. By means of this compression the interior layers are rendered more dense, horny, and compact; and such portions of them as can no longer find room in their former position are forced upwards, the elongation being facilitated by the ascent of the sap through the vascular system, and by the consequent deposit of additional substance.

We thus find the woody layers gradually assuming a

tapering or conical form (Fig. 6), and elongating themselves year by year, so that a large proportion of those visible at the butt are traceable at the upper part of the stem. A given diameter of wood consequently contains many more layers at the top than at the butt end of the tree.

The following table is given to show the number of concentric rings counted in the butt and top ends of four very fine English Elm trees :—

TABLE I.

No.	Length.	Calliper Measurement.	Butt-end.		Top-end.		Percentage of layers at top.	Wood made per year.	No. of layers to one inch.	
			Diam.	Annual layers.	Diam.	Annual layers.			Butt.	Top.
	Feet.	Cub. ft.	Inches.	No.	Inches.	No.		Cub. ft.		
1	44	158	36	89	18	56	63	1·78	2·47	3·10
2	41	233	36	80	18	74	92	2·90	2·20	4·10
3	35	170	36	66	18	62	94	2·57	1·83	3·42
4*	49	355	48	97	18	85	88	3·66	2·02	4·70

From the examples here given, we find that about 84 per cent. of the layers seen at the butt were traceable at the part where the tree was topped off. We also see by the number of layers in one inch of wood at the top, as compared with the butt end, the approximate taper of the cones just referred to.

It is very generally admitted that, in latitudes having the seasons clearly defined as they are in this country, each circle of lignine is completed in one year, but opinions differ as to this being the case in tropical climates, and there are botanists who consider that as

* This tree, when cut at 25 feet from the butt, was found to have ninety-two layers at that point.

many as three or four layers are formed in those regions in the same period of time. Relying, however, on the generally recognised rule, of one circle or layer for each year's growth, we have a measure and guide for computing the age of a tree at the time of felling it. Of course, this can only be done with trees having clearly defined concentric circles; in the instances exceptional to this, we, of necessity, have to fall back upon historical or traditional records to satisfy our inquiries.

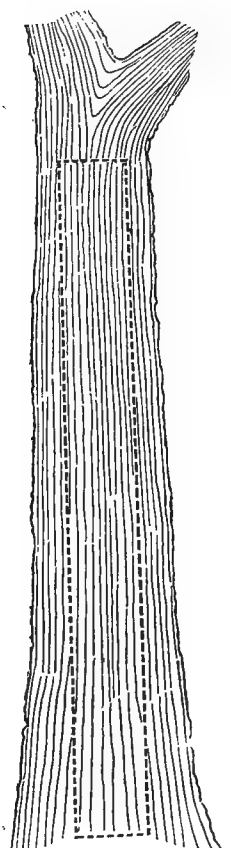

FIG. 6.

It may be interesting here to note the size and age which some species of trees attain. It is said that specimens of the "Baobab" of Senegal are more than 5,000 years old, and that some of them have a girth of 90 feet. Again, some cedars that were seen in Lebanon in the sixteenth century were considered to be the remains of the forest from which the timber was drawn to build the temple of Solomon. By tradition, and other reasoning, the age of these Cedars was set down at about 3,000 years. Maundrell men-

tions that the largest he measured of this species was about 36 feet in diameter.

Decandolle gives the following list of the ascertained ages of the undermentioned species of trees :—

Elm	335 years.	Lime . . .	1,147 years.
Cypress . . .	350 ,,	Oak . .	810 to 1,500 ,,
Larch	576 ,,	Yew . .	1,214 to 2,820 ,,
Cedar	800 ,,	Adansonia . .	5,000 ,,

These figures have, doubtless, been based and computed upon the supposition I have advanced of there being one concentric circle for each year of growth ; but, as they do not serve us for any practical purpose, we must look to those trees of moderate dimensions, which attain to maturity in a shorter time, rather than to those I have enumerated, for the timber we may wish to employ for architectural works. The record, however, which these circles afford of the duration of life in trees possesses a value of which we cannot but feel the importance.

I have carefully examined and counted the annual layers of a great many specimens—taking generally an average of ten trees—with the view to show the common and comparative rates of growth, and have tabulated them to afford an opportunity of noticing any variations there may have been in the time required to form the wood in each of the several given diameters of 6, 12, 18 inches, &c. This evidence of the ordinary rate of growth, and the time which it takes to bring the various descriptions of timber trees to maturity, will be of value to us when considered in connection with the properties and characteristics of the timber employed for architectural works.

The number of concentric circles, or woody layers, found in various timber trees, within a radius of 3, 6, 9,

12, 15, 18, 21, and 24 inches, measured from the pith, or centre, are shown in the following table :—

TABLE II.

No.	Description.	Diameter of the Stem. Concentric circles, or woody layers, in								Number of trees examined.	Average number of layers to make one inch at 24 in. diam.
		6 in.	12 in.	18 in.	24 in.	30 in.	36 in.	42 in.	48 in.		
1	Oak, English .	22	34	51	68	...	...	...	...	10	2·84
2	do. do.* .	12	20	28	36	44	53	64	76	10	1·50
3	do. do.* .	13	19	24	30	37	40	44	49	1	1·25
4	do. French. .	18	34	47	60	...	...	...	...	10	2·50
5	do. Roman. .	15	28	43	62	76	...	...	...	10	2·60
6	do. Sicilian .	24	44	65	87	104	...	...	...	10	3·60
7	do. Neapolitan	19	37	58	72	86	110	128	...	15	3·00
8	do. Sardinian .	25	45	65	89	...	...	...	...	10	3·70
9	do. Dutch or Rhenish	29	56	81	107	140	...	...	...	6	4·45
10	do. Dantzic .	27	58	87	...	...	...	...	...	6	4·83
11	do. Spanish .	36	81	130	...	...	...	...	...	4	7·20
12	do. Turkish .	...	...	...	...	...	...	...	...	3	12·00
13	do. American White	36	63	89	112	129	...	...	...	10	4·70
14	do. do. (Baltimore)	46	82	137	183	...	...	...	...	10	7·60
15	do. do. (Canadian)	49	105	160	216	...	...	...	...	4	9·00
16	Teak, Burmah (Moulmein)	27	47	71	96	...	...	...	...	10	4·00
17	do. do. (Rangoon . .	27	60	87	114	...	...	...	...	5	4·75
18	do. Malabar .	19	40	64	90	...	...	...	...	10	3·75
19	do. Siam . .	28	59	88	118	...	...	...	...	5	4·90
20	Pyengadu (Iron-wood), Burmah	...	...	...	...	...	...	...	...	3	†
21	Chow, or Menkabang Penang, Borneo	...	...	...	...	...	...	...	...	4	3·00
22	Pingow do. .	...	...	...	...	...	...	...	...	4	†
23	Kranji do. .	...	...	...	...	...	...	...	...	4	†
24	Kapor do. .	...	...	...	...	...	...	...	...	4	7·00
25	Molavè, Philippine Islands	...	...	...	...	...	...	...	...	3	†

* These were trees of magnificent growth and first quality. † Not clearly traceable.

TABLE II.—*Continued.*

No.	Description.	DIAMETER OF THE STEM. Concentric circles, or woody layers, in								Number of trees examined.	Average number of layers to make one inch at 24 in. diam.
		6 in.	12 in.	18 in.	24 in.	30 in.	36 in.	42 in.	48 in.		
26	African, Sierra Leone	40	69	94	118	...	...	...	...	10	4·90
27	Greenheart, Demerara	37	60	83	...	...	...	...	...	3	4·60
28	Mora, Trinidad	30	53	76	102	...	...	...	...	6	4·25
29	Carapo do.	...	...	...	...	...	...	...	...	2	5·00
30	Balata do.	...	...	...	...	...	...	...	...	2	8·00
31	Sabicu, Cuba	32	57	88	134	...	...	...	...	10	5·60
32	Mahogany do.	31	55	76	100	...	...	...	...	10	4·20
33	do. Honduras	25	43	60	77	...	...	...	...	10	3·20
34	do. Mexican	17	30	44	59	73	...	...	...	10	2·45
35	Santa Maria	28	59	86	117	...	...	...	...	3	4·87
36	Tewart, Australia	23	45	63	93	...	...	...	...	10	3·90
37	Jarrah do.	...	...	...	...	...	...	...	...	6	*
38	Iron Bark do.	...	...	...	...	...	...	...	...	3	4·00
39	Blue Gum do.	...	...	...	...	...	...	...	...	2	3·30
40	Stringy Bark do.	...	...	...	...	...	...	...	...	3	*
41	Kari, Western do.	18	37	59	82	108	...	...	...	3	3·41
42	Ash, English	19	36	54	70	...	...	...	...	6	2·90
43	do. American	36	77	116	152	...	...	...	...	4	6·36
44	Beech, English	17	33	50	68	...	...	...	...	6	2·83
45	Elm do.	21	34	45	67	...	...	...	...	10	2·80
46	do. do.*	10	16	25	36	48	61	82	101	1	1·50
47	do. Canada	80	156	252	...	...	...	...	...	10	14·00
48	Fir, Dantzic	23	49	85	116	...	...	...	...	10	4·82
49	do. Riga	29	60	96	124	...	...	...	...	10	5·20
50	do. Polish	29	55	88	137	...	...	...	...	10	5·70
51	do. Spruce	68	...	...	...	...	...	...	...	6	11·40
52	Pine, Canada Red	16	34	66	123	...	...	...	...	10	5·13
53	do. do. Yellow	28	73	102	125	...	...	...	...	10	5·22
54	do. American Pitch	32	61	98	147	...	...	...	...	10	6·12
55	do. Oregon	17	46	77	104	...	...	...	...	2	4·32
56	do. New Zealand Kauri	53	95	130	161	207	247	...	...	4	6·70
57	Larch, Polish	23	52	90	132	...	...	...	...	7	5·50
58	,, Russian	27	64	108	130	...	...	...	...	10	5·42
59	,, Italian	...	...	...	...	...	...	...	...	...	...
60	Cedar, Honduras	13	22	31	43	58	70	...	...	10	1·95

* See Note (†) on p. 17.

The measurements in the foregoing table were taken at consecutive distances of 3 inches from the pith of trees having well-formed concentric rings, and by doubling this, the diameters of 6, 12, 18, 24, 30, 36 inches, &c., were obtained. There are only two or three of these results that can be compared with the list furnished by Decandolle, but severally they will be found useful for reference; and, later on, I shall have occasion to revert to some of them, when treating of the characteristics of the individual kinds to be noticed in these pages.

The proportion which the width or thickness of each layer at the upper bears to that at the lower extremity of the tree, varies considerably in the several species, the difference being the least marked where there is the greatest length of clear stem. Indeed, as the sap which goes to form a branch must be regarded as so much matter diverted from the trunk itself, it follows that in a tree in which the branches occur low down, the stem will taper more than in one which has them only near the top. The diminution in the thickness of the layers will be most apparent in the trees which produce the largest branches, and will be regular or irregular according as the branches are thrown out at regular intervals or otherwise.

It might be supposed that as every layer from the pith, or medulla, to the bark is in a different stage of perfection, the innermost or earliest, being the most matured, would be the strongest; but experience teaches us that this is only true up to a certain period of growth, and that in the majority of cases the maximum of strength and toughness lies nearer the more recently-formed heart-wood, or duramen. For this reason it becomes a matter of great importance, in selecting timber for use—especially if it be intended for works of any

magnitude—that logs should not be taken of dimensions much in excess of the specification given, but corresponding as nearly as possible in size to it, as the removal of more than a few of the outer layers of heart-wood is likely to involve a serious loss of strength.

It should be observed that a tree does not cease growing when it arrives at maturity. As long as it is alive, it continues to increase in bulk by the addition of the annual layer; but when maturity is once passed, each succeeding year produces a certain amount of deterioration at the centre. This deterioration or decay appears in various stages, and generally exhibits, in the first instance, either a white or yellowish-red colour at the butt or root end of the stem. If white, the defect is probably very slight, and does not usually extend more than a few feet up; but if yellowish-red in colour, it is not unfrequently of a more serious character. Again, if the affected parts have assumed a decidedly red tinge, the tree is said to be, in technical language, "foxy," and is scarcely fit for constructive purposes, as the decay will be found to pervade a great portion of the tree. The further advanced stage of deterioration is that which may be described as a drying up or wasting away of the wood immediately surrounding the pith, or medulla. It forms a hollow, first at the butt, and then spreads upwards, gradually increasing in size as the tree gets older, while the defect may eventually reach even into the branches.

Trees are of course most valuable, as yielding the largest possible amount of good timber, just prior to the commencement of this change, which is indicated almost immediately it takes place by the topmost branches and branchlets becoming stunted and thick; being, in fact, what the surveyor or woodman would call "stag-

headed." If, therefore, we wish to select a healthy tree for felling, we must seek for one with an abundance of young shoots, and the topmost branches of which look strong, pointed, and vigorous, this being the most certain evidence that it has not yet passed maturity.

Timber trees, immediately after they are felled, unless they have been previously killed, contain a great deal of moisture, and are, therefore, unfit for use until they have been somewhat seasoned. This is accomplished in a variety of ways, but the primitive and best mode is, probably, to leave it for a time protected from the weather, following as closely as possible the natural process, which consists simply of the gradual drying up, or evaporation, of this moisture, which would otherwise form the first elements of decay. Of the time required for seasoning, and the various means of accomplishing it, I shall have occasion to notice farther on; suffice it to say at present, that as the wood which needs the least seasoning is generally found to be the most durable, it becomes an essential point that trees should be felled during the winter months, when the sap is present in its smallest quantity.

CHAPTER III.

ON THE FORM AND QUALITY OF TREES.

TREES grown in sheltered places run up quickly and to a great height; they also produce the greatest length of clear stem, the upward development preventing the growth of branches low down. This is probably owing to the want of sufficient light and air to enable them to respire freely, and in situations where it occurs the texture of the wood is soft in comparison with that of trees grown in the open. They have, however, the compensating advantage of being very free from local defects.

Many trees, as, for example, the Oak, when grown in hedge-rows, or other exposed and isolated places, enjoying a healthy circulation of air, take a freer and, perhaps, more natural form of growth; the branches generally occurring lower down, and meeting with no obstacle to their development, they assume every variety of curve, and produce timber which is especially valuable for naval purposes. Timber thus grown is of the hardest and most compact kind, although subject to many defects from the want of shelter from cold winds; the occasional breakages of the branches from various causes; and the injudicious lopping or pruning, which is too often practised.

Trees grown in a copse might be expected to unite the leading characteristics of the two forms of growth just mentioned, inasmuch as, while the underwood remained, the upward tendency of the stem would be almost as strong as in a forest-grown tree, while each time the copse was cut, the branches would have perfect freedom of growth. It is, however, found that, although forming curved branches and a greater length of stem than can be met with in isolated trees, instead of the wood being uniformly harder, the changes of temperature to which the trees are subjected by the periodical loss of the protecting underwood renders the quality of such timber extremely variable.

Variety of soil also exercises a direct influence upon the quality of timber; trees grown in a dry, rocky soil having generally hard, compact wood; while the wood of those grown in swampy and moist situations will be found comparatively soft and spongy in texture. Variations of temperature, violent storms, or proximity to the sea or large rivers, will also affect the quality and rate of growth of trees.

It has long been supposed that the presence of trees tends directly to keep up the water supply, and that the clearing of large forests results, in time, in the drying up of all the springs and watercourses in the neighbourhood. That such an effect is produced is certain, as attention was lately drawn to it by the condition of large tracts of land in the South of France and other districts, which, though long celebrated for their fertility, were rapidly becoming valueless. The change in the nature of the soil, consequent upon the partial drying up of all the sources of water supply, was proved to have commenced when the trees had been removed. At the same time, it is said that in places where there

had always been a deficiency of water, the extensive planting of trees has remedied the defect.

It would seem that the fine trees found in forests and elsewhere, whether it be natural to them to have straight stems or curved ones, have not always been so fair looking or so symmetrically shaped as we find them when of an age and size fit for felling, but that in early life they have not unfrequently assumed a wavy, rambling, or, it may be, unsightly appearance, which was only improved upon as they attained to greater strength and approached maturity. This supposition will, I think, be readily allowed by anyone who has passed through a copse, or maiden forest, in search of a straight sapling for a walking-stick, and experienced the difficulty of finding one suitable for the purpose.

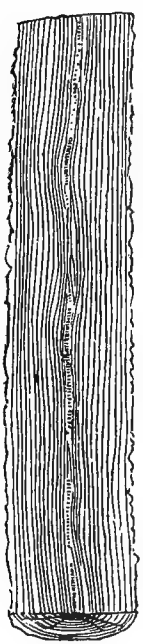

FIG. 7.

A short time since a piece of Oak timber of moderate dimensions came under my notice which fully illustrated this fact, as it had sufficient of its wavy and rambling form laid open, while under conversion for employment in ship-building, to satisfy the most sceptical that it could have had little of beauty to recommend it to notice during the first thirty years of its growth; while the large straight block of timber which encased it showed that later in life it had assumed a much fairer form, and was even considered, when

viewed in the log, to be fit for any purpose where straight timber was required.

It is, therefore, clear that trees do not change or alter their form while young, except in a very slight degree; they appear rather to assume the fairer and more even growth later on, and very gradually. It may possibly be brought about by the matter which forms the zones of each succeeding year's growth contributing to one part a greater and to another a lesser substance of woody layer, as required to develop the fairer growth seen in the matured tree referred to. And hence, if we take a perfectly straight tree, and cut it through the middle longitudinally, we are pretty sure to see the pith running snake-like along its entire length (Fig. 7). Therefore, in timber having much heart-shake, there is certain to be considerable waste in its conversion, especially if we wish to reduce the log into plank and board.

CHAPTER IV.

ON THE DEFECTS FOUND IN TREES.

HAVING described the characteristic points of growing timber trees, it will perhaps be interesting if, before proceeding to a detailed account of the various kinds, we were to give a description of some of the defects to which trees are liable prior to their being felled and hewn, or otherwise prepared for the market.

There is one defect so common to nearly all trees, that I will treat of it first. It is known to carpenters as the heart-shake. It is met with to a greater or lesser extent in nearly every species of timber that we have to deal with, and as it has a very important bearing upon the value of the tree affected, we cannot afford to disregard it, inasmuch as the quantity of good and serviceable material obtainable from a log, depends almost entirely upon the distance we are constrained to go from the pith, or centre, in order to get clear of it. Experience has shown that among the woods least affected by the heart-shake are African Oak, or Teak, as it is sometimes called; Sabicu; Cuba Mahogany; and English Elm; while Indian Teak * and Australian Tewart have it in

* In India, the forest officers have attributed the heart-shake in Teak to the ringing, or barking, the trees, to kill them before they are felled. It has, however, been proved that, where this has not been done, and the trees were felled green, heart-shake was found in them.

a very objectionable form. These species are among the hard and strong woods used for architectural purposes in this country, and by cabinet-makers for the manufacture of furniture, and for other domestic uses.

As regards the white or softer woods, it is generally very small in the Dantzic, but extensive and open in Riga and Swedish Fir. In the Pines, the Canadian Red is perhaps the closest and least of all affected by it, the Canadian Yellow coming next in order; but in the Pitch Pine of the Southern States of North America it is often present in a more enlarged form, and the centre, or pith, of this species cannot well be approached if thin boards are required to be cut from it.

This defect, as before mentioned, affects and pervades more or less nearly every description of timber; it is common to all the exogenous trees, and neither age, soil, nor situation appears to have anything to do with its origin. It must consequently be accepted as an arrangement in the natural order of things for which there is no help, and our study should be to so utilise the trees possessing it in its most extensive and objectionable form, as to employ them for purposes which require their full growth, doing as little as possible to them if we wish to convert the logs profitably. The heart-shake is, nevertheless, so very insignificant in some timber, that many persons, not professionally educated to the work, might look at a log without suspecting its presence. Others, again, if they did discover it, would hardly consider it to be of any importance, as it is often so small that the blade of a penknife could scarcely be thrust into it.

There are, however, several varieties of timber which have it, not in an insignificant form or shape, but extending from the pith to a distance of about two-

thirds the semi-diameter of the tree. This is of serious consequence to the converter who has to deal with it, as the defect completely separates the concentric layers into segments of circles. The simplest form in which we find this shake (Figs. 8 *a* and *b*), is that of a straight line crossing the pith, and taking a direction in the same plane through the length of the stem. It will, however, be found in some specimens to have taken a twisting form, and on examining the top of the tree, the shake may be nearly at right angles to that at the butt-end (Fig. 9). This is about the worst form, as it would involve a most serious loss in the conversion of the log if it were an object to reduce it into plank, and often necessitates its being employed in bulk.

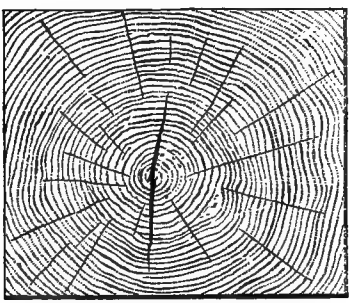

FIG. 8*a*.

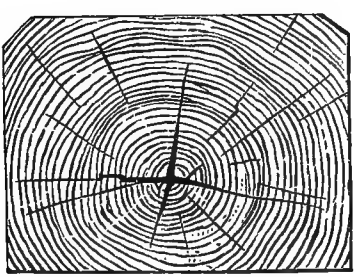

FIG. 8*b*.

The twist in the heart-shake just referred to is probably the result of an effort made by the tree to turn upon its base, which, I should think, might happen to trees produced in dense forests, where light and air are

very scant, or perhaps to trees unequally balanced in their branches, if grown in the open. There is something like evidence of this twisting in the spiral turns of grain noticed in many trees.* The heart-shakes are equally disadvantageous, if, indeed, they are not more

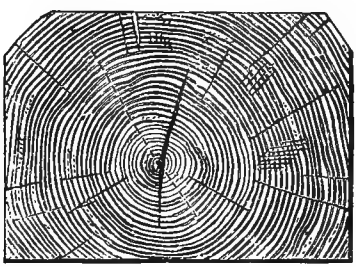

FIG. 9.

so, when they cross each other at the pith, and open to the full diameter of the tree, splitting it into four segments. This form of the defect is very conspicuous in the Green-heart timber (Fig. 10).

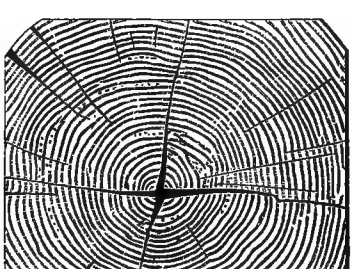

FIG. 10.

* This spiral growth is common in the Turkey Box tree ; it is also frequently seen in the Fir and Pine species, and occasionally in other woods.

CHAPTER V.

ON THE DEFECTS IN TREES—(*Continued*).

THE next important defect is the star-shake (Fig. 11). This is found in many varieties of timber, and occurs in trees of all ages and conditions of growth. It consists of clefts radiating from the centre, or pith, which often extend far towards—and even in bad cases touch—the circumference of the tree, rendering it almost valueless for conversion into board and small scantlings.

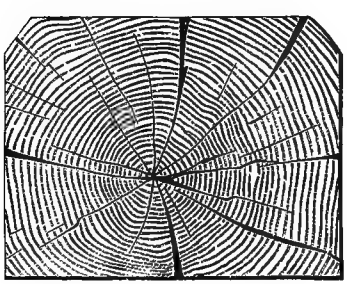

FIG. 11.

The clefts or lines forming the star are generally only slightly open, and can scarcely be seen in a fresh-cut tree, there being no decay of lignine about them. They are, however, very plainly perceptible when the wood is moderately seasoned, by the matter forming the two sides of the shake having become somewhat darker in colour and more horny in texture by exposure to the air.

As before stated, in bad cases the points touch the circumference of the tree; they even occasionally bulge there, forming a longitudinal rib, varying in length from

about a foot to two or three yards. We have thus external evidence of the presence of the star-shake in this extreme case while the tree is yet standing. We can, therefore, from this alone, estimate its value, and prove the correctness of our opinion of it after the tree has been felled. No one, I imagine, experienced in timber-surveying, would, with the bulging rib in view, care to examine either the top or butt end of the log to satisfy himself of the presence of the star-shake; the guide is so absolutely certain that we need not fear to trust to it.

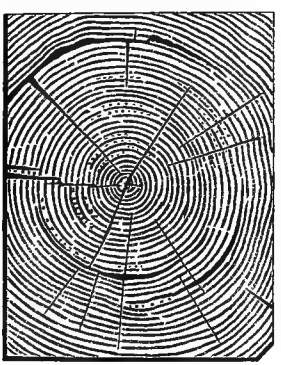

FIG. 12*a*.

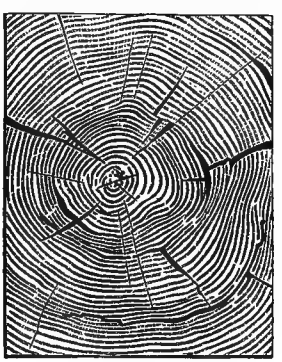

FIG. 12*b*.

My experience will not enable me to account for the star-shake, and I do not remember to have seen any reasonable explanation given in any work respecting it. I may state, however, that it is more frequent in trees which have been grown upon either a sandy or a rocky soil, than in those which were grown upon loam or stiff clay.

The cup-shake (Figs. 12 *a* and *b*). This shake, which is most frequently met with near the roots of trees, consists of a cavity or separation of two of the con-

centric layers, and probably arises from the sap failing to possess some of the elements necessary for uniting the new layer to that of the previous year's growth. This deficiency of the cohesive matter between the woody layers is supposed to result from sudden changes of temperature, from the roots passing through a peculiar vein of soil, and even from frosts; violent and sudden gusts of wind and storms may also help to produce it.

It will sometimes happen that only a portion of a layer is detached, making the segment of a cup; at other times, a small part of several layers; and again, in some instances, we find that the disjunction is not complete, owing to there being a few fibres remaining to connect the two layers. When, however, it assumes its worst shape, that is, when the ring or cup is perfect, it will in all probability be found to pervade the greater part, if not the whole tree, evidence of it being frequently traceable in the remotest branches.

Experience has shown that with only a segmental cavity open, there is not much to fear, as it seldom extends far up from the root; any log, therefore, not having more cup-defect than this, may without hesitation be converted into plank, board, or scantling; but if one or more complete cups be present, especially if they are large, it could not safely be sawn longitudinally down the middle, as the centre or cup part would drop out, leaving in each half a deeply-grooved channel, equal to the semi-diameter of the cup-defect. The log in this case could, therefore, only be used advantageously by appropriating it to some purpose, where the full growth might be employed.

The cup-defect occurs in perfectly sound and healthy-looking trees, and there is not anything to indicate its

presence to the surveyor while the tree is standing. It can only, therefore, be dealt with when discovered in the log, after being felled. This defect is, to some extent, local, and is especially so among the Oaks, it being more frequently met with in the Sicilian Oak than in, perhaps, any other. It occurs in Virginian Pitch Pine, and it is often found in Lignum Vitæ. It is worthy of notice that whatever may be the cause of the cup-shake in the last-named wood, which is grown extensively in St. Domingo, latitude 18° to 20° N., and where the temperature of the winter is rarely below 60°, it cannot have suffered from frost.

CHAPTER VI.

ON THE DEFECTS IN TREES—(*Continued*).

WHERE woody layers of irregular growth are found in timber, especially if there be alternation of colour extending over many of them, they may be considered to indicate that the tree was not at all times in a healthy state, but that it had suffered from some cause, or from the failure in the nourishment it required to perfect the layers with regularity.

Any departure, therefore, from the natural colour peculiar to the species, whether it embrace one or more concentric circles, or be locally situated, is prejudicial to the wood, and generally, if tried under the adze or plane, it will be found brittle and deficient in tenacity. Such logs should on no account have the preference of selection for important services in works of construction, but should rather be used for minor purposes. I have noticed this defect in many varieties of trees, but in none is it more conspicuous than in the Kauri of New Zealand, these noble Pines being peculiarly liable to this whenever they stand exposed upon the north or equatorial side.

We occasionally see spots in timber, quite foreign in colour to that which is natural to it; they may be seen in all parts, but are most common at or upon the butt-end of the log. These are not often of a very serious

character, but are nevertheless the early or first stage of incipient decay, and will be found less able to resist the action of water than the wood of the same log which is untainted. Although these spots can hardly be reckoned as defects, seeing that they do not penetrate deeply enough to affect in any appreciable degree the value of the timber, the surveyor would do well not to employ such logs in architectural works where it would be difficult to replace the piece should it at any time be found to be decayed.

A swelling upon the exterior of a tree is generally a sign of some defect being hidden beneath; it may be confined to the alburnum, but it may also conceal a serious fault that would be highly detrimental to its value.

The excrescence should, therefore, be removed as soon as the tree is felled, in order to clear up the existing doubt. There are, however, some few exceptions to this; for instance, the burrs which are found upon the Oaks of some districts,* and the Austrian and Turkey Walnut tree burrs, which are very finely mottled and figured, make good veneers, and have of themselves a special value for cabinet purposes.

The removal of a branch of moderate size from a tree, close down upon the stem, will generally be concealed by a swelling of the kind first mentioned, particularly if it has been done while the tree was in a healthy state and annually forming new wood. Such hidden knots are frequently in a state of incipient

* These peculiar excrescences are supposed to be caused by puncturations of the bark by insects, while the tree is growing; but, so far as I am aware, the quality of the trunk of the tree is not often affected by it.—*Vide* Description of the Walnut Tree, page 111.

decay, owing to the rain and the moisture of the atmosphere having entered by the wound, before it became hermetically sealed; and, as it generally takes a long time, even many years, to completely heal it over, it would during all that while be steadily producing decay in the fibres, running from the knot to the centre of the tree; the diseased or affected part, when opened, being often found spread to a very great extent, and in bad cases emitting an unpleasant odour.

FIG. 13.

The disease thus occasioned first attacks the alburnum, and the fibres immediately surrounding the centre of the knot, and then passes downwards, following the direction of the wounded branch towards the pith of the bole or stem, after which it rises with the sap, and is often communicated to other parts of the tree, and does very great mischief.

It will sometimes happen that this disease is concentrated, or confined to the root end of the branch, producing there what is technically termed a "druxy knot." This defect, if prevented from spreading by the otherwise healthy and vigorous state of the tree

during its growth, must still be looked to after it is felled, since, if neglected, there being no longer any check to its development, fresh moisture will be absorbed, decay will be accelerated, and the whole log soon destroyed. To guard against this, it would be proper, as soon as the log is appropriated for any purpose, to take out and completely remove the affected part, substituting in its place a piece of sound wood.

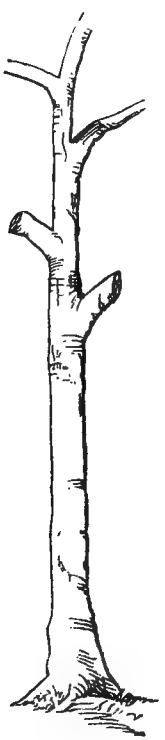

FIG. 14.

Again, the damage done by the breaking of a branch from a tree is often very serious, as illustrated in Fig. 13. The wound was of very old standing, and entirely healed over, but the decay had nevertheless made steady progress. It was found, by counting the concentric layers, that the branch was broken when the tree was fifty-six years old; that in twenty-three years more the annual layers had completely covered the broken part, while outside this twenty-third layer there were twenty-seven years' growth of duramen or heart-wood, and twenty-six years' growth of alburnum or sap, the tree having been about 132 years old at the time of its being felled.

Pruning closely, except in the case of very young trees, where the branches are small, and the wound is certain to be soon healed over, will, as before shown,

be attended with some danger, and should not, I consider, be done if it can be avoided. The safer plan with trees of moderate growth is to let a part of the branch remain; say a foot or two in length, taking care at the same time not to leave it rugged at the end.

It should be neither cut horizontally nor square to the branch, but perpendicularly, or in the direction most certain to prevent water lying on the surface (Fig. 14).

A tree is occasionally wounded and damaged by a blow. It may have been struck by the fall of another contiguous to it, or in some other way; but such bruises often penetrate no farther than the bark, and simply leave evidence of it later on, in what is technically termed "rind-gall" (Fig. 15). This is a defect, inasmuch as the concentric layers at this part are not solidified upon each other; but there is usually no decay of the fibre. If, however, the injury be more severe, and the alburnum and duramen are contused, the wounded part no longer resists, but largely absorbs moisture, which tends directly to decompose it, and, decay having once set in, a species of rot soon supervenes, to the detriment of the tree. This is often difficult to discover while the tree is standing, as, unless the blow is of quite recent date, the bark will have grown over it again, and effaced every trace of the wound.

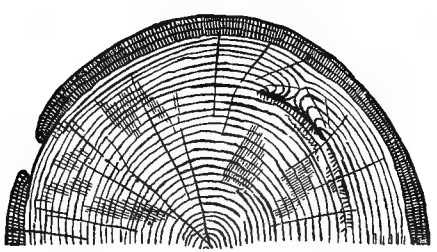

FIG. 15.

The following remarks on the selection of timber, &c., may be useful :—

In selecting timber, the surveyor's attention will naturally be given to an examination of the butt or root end, which should be close, solid, and sound; and if satisfied in this respect, the top should next be inspected, to see that it corresponds with the butt-end. Afterwards he will glance over the exposed sides in search of defects, carefully examining the knots, if any, to see that they are solid. He will, of course, avoid any piece that has either heart, cup, or star-shake, or sponginess near the pith at the butt, discoloured wood at the top, splits along the sides, rind-gall, worm holes, or hollow or decayed knots.

In dealing with spar-timber, he will select the straightest pieces; they should be free from all the defects before mentioned, upsets, *i.e.*, fibres crippled by compression, large knots, and even those of moderate size if they are numerous or situate ring-like round the stick. Spar-timber should be straight-grained.

As planks, deals, &c., depend for their usefulness upon both quality and manufacture, the surveyor will not only see that they are free from excess of sap, knots, shakes, and shelliness upon their sides, but also that they are evenly cut and fit for use of their thickness.

Bright-looking timber is better in quality than dull, and that which is smooth in the working better than the rough or woolly-surfaced.

The heart of trees having the most sap-wood, is generally stronger and better in quality than the heart of trees of the same species, that has little sap-wood.

CHAPTER VII.

EXPERIMENTS ON TIMBER.

HAVING treated of the principal defects to which timber trees are liable during their growth—and perhaps they are all that need be now considered, as others of a less important character will be noticed later on, whenever they affect any particular class of wood—I will pass for the present to the description in detail of the various timber trees, observing, by-the-way, that the tables appended are the results of experiments made transversely, tensilely, and vertically on specimens taken from the wood of the tree described. In some cases these are very numerous, and will be, I consider, invaluable, as showing the range and variation of the strength and specific gravities of each wood; further, they include some rare, and at present scarcely known, species of timber, which may at a future day be in request in this country for building purposes.

It need scarcely be stated here, since it will be well understood, that to classify and collect the notes in order to record these tests of strength, &c., in timber, it has taken a very long time, and, but for the exceptional opportunities I had during a long course of service in the royal dockyards and elsewhere, it would have been impossible for me to have obtained these results.

While employed surveying timber for the Navy in New Zealand, and subsequently in India, Belgium,

France, Prussia, Asia Minor, and European Turkey, and also in the royal forests in England, and later on as Timber Inspector of a dockyard, and Timber Inspector to the Admiralty, every effort has been made to acquire a knowledge of the capabilities and characteristic properties of the several varieties of timber which came under notice.

Many of the experiments to which I shall have to refer were made at Woolwich Dockyard, where it was necessary, as a part of the duty of my office, to ascertain the specific gravities, strength, and measurement, and attend to the receipt of the timber coming in under contract with the Admiralty.

Especial care was taken to carry out the experiments upon wood brought to a well-seasoned condition and fit for appropriation to works of construction; and in many instances we have tried not only a number of pieces taken from different trees, but a series of pieces from the same tree, with a view to find, if possible, in what part the maximum of strength lay.

Formerly, I believe, it was the practice to carry out these experiments upon exceedingly small pieces of wood, and I have seen it stated that some were no bigger than a French line,=·0888-inch measurement, and varying in size from that to about one quarter of an inch of English measure, the result per square inch being obtained by subsequent calculations. This was probably done in consequence of the great difficulty there is in securely holding, and bringing a sufficient strain to bear upon and break the larger scantlings. I should not, however, be disposed to place much reliance in the results so worked out, as it would seem to be impossible to reduce pieces of wood to such small dimensions without cutting across some of the fibres, and thus

unnecessarily weakening those which remain. There are, undoubtedly, many examples to be found where larger scantlings have been experimented upon, and the results of these are, of course, more reliable and trustworthy.

The tests for the transverse strength in my experiments were conducted, in every case, with pieces $2'' \times 2'' \times 84'' = 336$ cubic inches. Each piece was placed upon supports exactly 6 feet apart, and then water was poured gently and gradually into a scale suspended from the middle until the piece broke, note being taken of the deflection with 390 lbs. weight, and also at the crisis of breaking.

After this a piece 2 feet 6 inches in length was taken, wherever it was found practicable, from one of the two pieces broken by the transverse strain, and tested for the tensile strain by means of a powerful hydraulic machine, the direct cohesion of the fibres being thus obtained with great exactness. Further, for the purpose of determining the proportions of size to length best adapted for supporting heavy weights, a great many cube blocks were prepared, of various sizes, as also a number of other pieces of different form and dimensions, which were then, by the aid of the same machine, subjected to gradually increasing vertical pressure in the direction of their fibres, until a force sufficient to crush them was obtained.

CHAPTER VIII.

THE OAK TREE (*Quercus*).

THE Oak is found to be more widely spread than perhaps any other tree. It has been met with in Europe in about 35° N., and is known to extend to 60°, or over 25° of North latitude. It is also found in the north of Asia, North America, and in Africa.

The Oak exists in very great variety, and England produces two, if not three, distinct species, in addition to numerous others, not native, but which are cultivated for ornamental purposes. The botanical names of those which are indigenous to this country are the *Quercus Robur pedunculata*, the *Quercus Robur sessiliflora*, and the *Quercus pubescens*, or Durmast Oak.

In the former, which is our best species, the footstalks of the flowers and acorns are long, while those of the leaves are short. In the *Quercus sessiliflora* this order is reversed, the footstalks of the fruit being short and those of the leaves long; while the distinguishing character of the *Quercus pubescens* consists in its having the under sides of the leaves somewhat downy, the footstalks of the fruit and leaves nearly resembling those of the *sessiliflora* variety. It is also peculiar to the leaves of the Durmast or pubescent species that they hang longer on the tree than those of either of the others.

It is the prevailing opinion that the wood of the *Quercus Robur pedunculata* is the best in quality, and that the *Quercus Robur sessiliflora* is slightly inferior to

it; but, while coinciding generally in this opinion, I feel bound to admit that, during a long experience in working them, I have not been able to discover any important difference between the two varieties.

We find, indeed, the wood of the two species so closely resembling each other, that few surveyors are able to speak positively as to the identity of either. It is only by tracing the log from the first fall of the tree to the hands of the converter that we are able to say that the timber of the *sessiliflora* is a little less dense and compact in texture than that of the *pedunculata.*

The Durmast Oak is only sparingly met with, and is of very inferior quality. Preference should therefore be given in all works of importance to the two species before mentioned; and in this there will be no difficulty, as they are easily obtainable.

It is fortunate that the *Quercus Robur pedunculata*, which is believed to produce the best timber, is to be found in greater abundance than the *sessiliflora*; and it is greatly to be desired that in any future planting, care should be taken to perpetuate it, although as a commercial speculation the *sessiliflora* would probably yield the best return, as it generally attains a greater length of clear stem.

Very fine specimens of these long, clear stems of the *sessiliflora* species are to be met with in abundance in the Forest of Dean, in Gloucestershire, where, upon a rocky subsoil, the Oak trees generally attain noble dimensions, with, however, this drawback—they are liable to the cup and the star-shake. Whether this is caused by the rocky nature of the soil, combined with the swaying to and fro of these tall trees by strong winds, or whether it is in some degree peculiar to the species, is not easily determined. I incline, however,

to the belief that these defects are less frequent in the *Quercus Robur pedunculata*, whatever the situation or soil may be upon which they are grown.

There appears to be little difficulty in rearing the Oak tree; it thrives in almost any soil, except that which is boggy or peaty; but to bring it to the greatest perfection, it is preferable to have a rich loam with a clayey subsoil. It will even spring up again from the old stool, or root, and without requiring any attention, produce, in time, one or more fine trees in place of that which was first cut down.

The following dimensions of nine Oak trees that were growing only a few years since (and possibly are so still) at Woburn Abbey Park, may be interesting, as showing the size they will attain upon a favourable soil. The particulars are taken from a small book, published in 1832, under the superintendence of the Society for the Diffusion of Useful Knowledge:—

TABLE III.

Oak Trees.	Height.	Circumference.
No.		
1	Stem 50 ft., measures at 3 ft. 6 in. from the ground	17 ft. 3 in.
,,	,, ,, ,, 20 ft. ,, ,,	14 ft.
2	,, 35 ft. ,, 4 ft. ,, ,,	17 ft. 9 in.
,,	,, ,, ,, 20 ft. ,, ,,	12 ft. 9 in.
3	,, 20 ft. ,, 4 ft. ,, ,,	13 ft. 0¼ in.
,,	,, ,, ,, 20 ft. ,, ,,	12 ft. 0⅛ in.
4	,, ,, 3 ft. ,, ,,	12 ft. 0½ in.
,,	,, ,, 66 ft. ,, ,,	8 ft. 0¼ in.
5	,, ,, 4 ft. ,, ,,	14 ft.
,,	,, ,, 56 ft. ,, ,,	9 ft. 0½ in.
6	,, ,, 3 ft. ,, ,,	14 ft. 4 in.
,,	,, ,, 34 ft. ,, ,,	12 ft. 6 in.
7	,, ,, 4 ft. ,, ,,	12 ft.
,,	,, ,, 50 ft. ,, ,,	8 ft. 0¼ in.
8	,, ,, 4 ft. ,, ,,	13 ft. 0½ in.
,,	,, ,, 50 ft. ,, ,,	8 ft. 0½ in.
9	,, ,, 3 ft. ,, ,,	13 ft. 0¼ in.
,,	,, ,, 48 ft. ,, ,,	8 ft. 0¾ in.

"It is stated that at the lowest estimate, the total quantity of timber in these nine trees amounts to 3,200 cubic feet of the very best quality for naval architecture, and that although they must be of great age, it is remarkable that no symptoms of decay appear in them. They are perfectly sound and free from blemish."

The characteristic properties of the British Oak are, upon the whole, so good, that it has long been accepted by practical men as a standard of quality and fitness for architectural purposes, and in the classification of all other hard and heavy woods in use in the royal dockyards, they are tabulated as "substitutes" for "Oak," the individual species, differing from it either in kind or specific gravity, or in having some important property attached to it, being only specially noted in the specification for building a ship whenever it is considered desirable to secure some particular element of lightness or strength, dissimilar to that of the standard.

The English Oak tree, if grown in sheltered situations or in forests, frequently reaches to a height of 70 to 100 feet, with a clear, straight stem of from 30 to 40 feet, and a circumference of 8 to 10 feet, and much larger specimens (though now only rarely to be met with) were formerly common. If grown in open and exposed situations, it is generally shorter, and frequently takes strange and eccentric forms, assuming a somewhat curved or crooked shape; this, however, is one of its most valuable characteristics, as naturally curved timber is almost indispensable for wood ship-building. It is when grown under these conditions that it appears to attain its maximum of hardness, and is often found so gnarled and knotty that it is difficult to work.

The long, straight, fair-grown trees, which yield the

largest proportion of useful wood, are most in request for the general purposes of the architect and engineer, but they are also fully appreciated by ship-builders, who employ them for beams, waterways, keelsons, &c.

Oak timber of the gnarled description, and having some figure in the grain, is in request for articles of furniture; and even when in a state of decay, or in its worst stage of "foxiness," the cabinet-maker prizes it for its deep-red colour, and works it up in a variety of ways.

The economical uses of Oak timber, and especially the English varieties of it, are, on account of its many valuable properties and freedom from excessive weight —the specific gravity being only about ·730 to ·900—so extensive that it would be impossible to enumerate the many useful purposes to which it is applied, while in wood ship-building it is invaluable, and, indeed, almost indispensable, as it is flexible enough to bear bending to the most curved and difficult parts in a ship's construction, without breaking.

The wood is light-brown in colour, hard, tough, and very strong; it does not splinter readily, and its solidity of character is such that it resists well the action of water. In seasoning it is apt to warp and shrink, although not to any considerable extent; consequently it cannot be used in a partially dried state without incurring some risk to the stability of the work; but when once its moisture is completely evaporated, few woods are liable to so little change, particularly when employed in situations where it is protected from the influence of moisture or draught. If subjected to alternations of wet and dry, it withstands the change better than most

other woods; while, if kept wholly submerged, there is scarcely any limit to its endurance.

Oak timber has, however, one drawback. It contains a powerful pyroligneous acid, which prevents its general employment in immediate contact with iron, as the metal, whether used for fastenings or otherwise, is subjected to a rapid corrosive action, while the timber is also liable to suffer by waste and deterioration.

British Oak timber has, for ages past, been a most important article in ship-building in this country, and it is still used for this purpose to a very great extent, notwithstanding the present very general use of iron as a substitute for it.

It was only within the last few years, that it was felt the quantity of Oak produced in England would soon be inadequate to meet the great and increasing demand for it, and that it was necessary efforts should be made to supplement it by the introduction of foreign Oaks and other hard woods for ship-building purposes.

To show this great necessity it will be sufficient to state, approximately, the store of ship-building timber which it was thought necessary to maintain at Woolwich Dockyard in the several quinquennial periods of the quarter-century ending in 1865. It will, apart from the ordinary demands of the private trade, serve to illustrate in some degree how large must have been the supplies annually required for all the royal dockyards, taken collectively, in order to replace the ships that were worn-out or had become obsolete, and to keep the ships of the royal navy up to the strength called for by the times.

The store of timber maintained at Woolwich Dock-yard suitable for ship-building was as follows, viz. :—

TABLE IV.

In the years	English Oak.	Foreign timber, or Substitutes for Oak.	Total.
	Loads.	Loads.	Loads.
1840	1,591	936	2,527
1845	1,029	2,196	3,945
1850	1,259	3,693	4,952
1855	1,868	4,596	6,464
1860	857	6,977	7,834
1865	5,490	14,077	19,567

The smallest quantity of English Oak at that yard at any one time within the thirty years ending in 1867 was 857 loads in 1860, and the largest 5,490 loads in 1865; while the smallest stock of foreign timber in store for use as substitutes for Oak was 936 in 1840, and the largest 16,771 loads in 1863. The smallest store of ship-building timber of all kinds held there during the same period was 2,356 loads in 1841, and the largest 21,012 loads in 1863.

The relative quantities of English Oak and its substitutes were kept up at all the yards, in proportion to the magnitude of the several naval establishments, and in 1860 there was the large quantity of 35,800 loads in the various stores, suitable for ship-building, exclusive of Elm, Fir, and Pine timber and plank; and this was very largely supplemented by later deliveries.

CHAPTER IX.

EXPERIMENTS UPON THE TRANSVERSE STRENGTH OF BRITISH OAK.

BRITISH Oak timber being, as before stated, generally recognised as the standard of quality, the greatest possible care was taken in preparing the specimens of the prescribed dimensions—2″ × 2″ × 84″—for the experiments to test its strength; further, the deflections under a weight of 390 lbs., as also that at the crisis of breaking, and the exact breaking weight each piece bore, were all taken, the results being shown in the tables which follow. It is hoped, therefore, that a sufficient guide is thus afforded, not only for comparing its strength with other woods, but also for determining the scantlings required for architectural purposes:—

TABLE V.—ENGLISH OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	3·500	·200	5·250	590	905	652	147·50
2	3·125	·312	8·500	825	682	1209	206·25
3	3·250	·125	11·000	1,002	708	1415	250·50
4	3·250	·125	6·500	797	725	1099	199·25
5	3·500	·250	7·000	804	720	1116	201·00
6	3·625	·125	5·875	637	670	936	159·25
Total .	20·250	1·137	44·125	4,655	4410	6427	1163·75
Average	3·375	·189	7·354	776	735	1071	193·96
E = 283410.				S = 2037.			

REMARKS.—Nos. 1 and 4 broke with a moderate length of fracture; 2, 5, and 6 with 9 to 15 inches and splinters in fracture. No. 3 was not completely broken asunder.

TABLE VI.—ENGLISH OAK.

Transverse Experiments.—Second Example.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inch.	Inch.	Inch.	lbs.			lbs.
7	1·625	·125	4·125	674	780	864	168·50
8	1·625	·250	5·250	837	753	1112	209·25
9	1·500	·187	5·000	824	770	1070	206·00
10	1·625	·125	9·500	977	1005	972	244·25
11	1·750	·000	9·250	882	1003	879	220·50
12	1·500	·000	8·750	827	1002	825	206·75
Total .	9·625	·687	41·875	5,021	5313	5722	1255·25
Average	1·604	·114	6·979	837	886	954	209·21
E = 605950. S = 2197.							

REMARKS.—No. 7 broke short: 8 and 12 with 7 to 13 inches length of fracture; 9, 10, and 11 with 15 inches scarph-like splintery fracture.

The Tables V. and VI. each refer to parcels of six pieces, which were taken from trees of good average quality and size, moderately seasoned, and fit to be applied to architectural works, the specific gravity varying from 670 to 905 in one set, and 780 to 1005 in the other. Of the twelve pieces tested, the elasticity of two, after the weight of 390 lbs. was removed, was perfect. One piece recovered its straightness to within ·312 inch, while of the remainder, nine in number, the elasticity was in all something better, though not quite perfect.

The deflections varied under this weight of 390 lbs. from 3·125 to 3·625 inches in one set, and from 1·5 to 1·75 inch in the other, the ultimate deflections at the crisis of breaking varying from 5·25 to 11·00 inches, and 4·125 to 9·50 inches, respectively; while the break-

ing weight varied from 590 to 1,002 lbs., and from 753 to 1,005 lbs., the average results of one parcel being 193·96 lbs., and of the other 209·21 lbs. on the square inch, the difference between the two being only 15·25 lbs.

Taking the mean of the figures in the Tables V. and VI., we have a deflection of 2·489 inches with 390 lbs.; but only ·151 inch after the weight had been removed, the ultimate deflection at the time of breaking being 7·166 inches, the breaking weight, 806·83 lbs., and the specific gravity 810. By applying the formulæ used by Professor Barlow, viz., $\frac{l^3 w}{16 a d^3 \delta}$ and $\frac{l w}{4 a d^2}$ respectively for elasticity and strength, we obtain the following result: E = 386400, S = 2116.

It should be borne in mind that in determining the scantlings to be employed, there are to be taken into account the possible chance of a short or twisted grain, a spiral turn of the fibre, knots, faulty or otherwise, and the risk which the practical builder must always run of having some defects hidden beyond the possibility of detection in, perhaps, his best-looking pieces. It would, therefore be obviously unsafe to subject them to anything like the strain which the ascertained average strength of the specimens tested would seem to warrant charging them with.

Considering the importance of this, it was determined to extend the experiments by testing a series of pieces taken from a longitudinal section cut through the centre breadth of a very fine-looking Oak tree. In setting out the specimens, the centre piece containing the pith and a very small heart-shake, was allowed to drop out as being of little or no value for the trial.

The six pieces cut from one side of the centre or pith

of this tree, came out with a long, clean, straight grain, as the appearance of the log had promised; but the six taken from the opposite side were not nearly so good, the grain being in each a little waved or twisted, and the fibre of no great length. Some had small pin-like knots in them, and the surface of the plank being dotted over with these, it presented a mottled appearance, somewhat resembling Bird's-eye Maple.

The specimens are numbered from the centre or pith of the tree outwards—1 to 6 and 1′ to 6′ in column 9. The results are as follow, viz. :—

TABLE VII.

Transverse Experiments.—3rd Example.

—	Number of the specimen.	Deflection. With the apparatus weighing 390 lbs.	Deflection. At the crisis of breaking.	Total weight required to break each piece.	Specific gravity.	Total weight required to break 1 square inch.	Direct cohesion on the square inch.	Number of the specimen in the tree.
The mean of 1′ to 6′ . . .	...	Inches. 3·25	Inches. 3·95	lbs. 407	867	lbs. 101·75	lbs.	
ENGLISH OAK.	13	3·75	3·75	390	836	97·5	...	6′
	14	3·75	3·75	400	866	100·0	...	5′
	15	...	3·50	390	868	97·5	...	4′
	16	...	...	390	865	97·5	...	3′
	17	...	3·75	390	860	97·5	...	2′
	18	2·25	5·00	480	910	120·0	...	1′
	19	2·00	7·00	740	900	185·0	5,320	1
	20	2·00	4·50	630	900	157·5	4,400	2
	21	2·25	5·00	620	854	155·0	4,200	3
	22	3·50	4·50	470	864	117·5	4,340	4
	23	3·75	5·00	480	838	120·0	2,520	5
	24	4·00	4·50	430	791	107·5	2,240	6
The mean of 1 to 6		2·916	5·10	562	858	140·5	3,837	...
The mean of the whole		3·083	4·525	484	862·5	121	...	...

REMARKS.—Nos. 13 to 17 inclusive broke very short; 18 and 19 were nearly alike, and had scarph-shaped fractures 10 inches in length; 20 and 21 had long splintery fractures; 22 to 24 inclusive broke short to ⅙th the depth, then long fractures.

In the specimens marked 1 to 6, the greatest strength was possessed by the piece taken from close to the centre of the log, which comprised the oldest and densest annual layers, while No. 6, which was farthest removed from it, and contained the most recently perfected duramen, proved to be the weakest, the respective breaking weights showing a difference of nearly 42 per cent.

Turning to the specimens marked 1′ to 6′, taken from the other side of the tree, we find a similar result as regards the inner and the outer layers, the greatest strength being again near to the centre of the tree; No. 5′, however, bearing the next greatest strain. The pieces Nos. 2′; 3′, 4′, and 6′, each broke as the weight of the scale was applied, and are therefore of little value.

We may gather, however, from the trial, that from the centre to the circumference of this tree there was clearly a diminution of strength, which, although not quite proportionate to the decrease observed in the specific gravity of the several pieces, is yet in some degree approximate to it.

I infer from this that the tree had not reached maturity when it was cut down, and that it was still in the prime of life. Had it been otherwise, we should have expected, when viewed by the light of other experiments, to find that the point of density and greatest strength would lie in the piece marked 4, or even farther removed from the centre.

There can be very little doubt that the wood of this tree, if used in its greatest bulk, or in any large scantlings, would have been found to possess fully the average strength of Oak timber, and that it was only weak in certain parts, as discovered on trial when cut into strips of 2 inches square. There still remains,

however, the fact that in a fine tree, sound and apparently free from defect, nearly the whole of one side was found to be faulty, while the other half proved to be inferior in strength to the specimens of average quality noticed in the Tables V. and VI., the mean breaking weight of the best side being 562 lbs., as compared with 776 lbs. in Table V., and 837 lbs. in Table VI., the weaker side not affording any figures by which it could be compared with previous experiments.

The deflections of a few specimens, under given weights and with various bearings, are shown in the following tables:—

DEFLECTIONS: ENGLISH OAK.

TABLE VIII.

Specimens: depth, 1½ inch; breadth, 2 inches; length, 84 inches; weighted with 300 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
25	795	·375	·750	1·187	2·500
26	785	·500	·875	1·750	2·750
27	782	·375	·750	1·625	2·500
28	775	·375	·750	1·500	2·625
Total . .	3·137	1·625	3·125	6·062	10·375
Average.	·784	·406	·781	1·515	2·593

TABLE IX.

Specimens as in Table VIII., weighted with 400 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
29	795	·625	1·00	2·00	3·625
30	785	·687	1·125	2·25	3·937
31	782	·437	1·000	2·25	3·562
32	775	·625	1·000	2·00	3·250
Total . .	3·137	2·374	4·125	8·50	14·374
Average.	·784	·593	1·031	2·125	3·593

TABLE X.

Specimens: depth, 2 inches; breadth, 1½ inch; length, 84 inches; weighted with 300 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
33	795	·312	·625	1·063	1·625
34	785	·250	·500	·875	1·500
35	782	·187	·563	·937	1·562
36	775	·250	·437	·875	1·562
Total . .	3·137	1·000	2·125	3·750	6·249
Average.	·784	·25	·531	·937	1·562

TABLE XI.

Specimens as in Table X., weighted with 400 lbs.					
Supports, apart.		3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Sp. gr.	Inches.	Inches.	Inches.	Inches.
37	795	·375	·625	1·250	2·125
38	785	·312	·625	1·125	2·000
39	782	·250	·750	1·187	2·125
40	775	·437	·625	1·312	2·000
Total . .	3·137	1·374	2·625	4·874	8·250
Average.	·784	·343	·656	1·218	2·062

Further experiments with reference to deflections were made upon a piece of English Oak, 2 × 2 × 84 inches, specific gravity 792, with the following result :—

TABLE XII.

Weighted with 300 lbs.				
Supports, apart.	3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Inches.	Inches.	Inches.	Inches.
41	·125	·375	·625	·875

TABLE XIII.

Weighted with 400 lbs.				
Supports, apart.	3 Feet.	4 Feet.	5 Feet.	6 Feet.
No.	Inches.	Inches.	Inches.	Inches.
42	·250	·500	·875	1·125

CHAPTER X.

ON THE TENSILE STRENGTH, OR DIRECT COHESION, AND VERTICAL STRENGTH OF BRITISH OAK.

THE tensile experiments are somewhat difficult to carry out, and therefore only specimens Nos. 1 to 6, Table VII., were tested from the log referred to at page 53. They varied from 2,240 to 5,320 lbs., giving a mean strength of 3,837 lbs. to the square inch, the wood next to the pith or centre proving to be the strongest, as with the transverse test. The gradations of strength, taking No. 1 as unity or 1·00, give No. 2 as ·82; No. 3, ·785; No. 4, ·81; No. 5, ·475; and No. 6, ·42, the tensile strength of the inner wood of this tree being therefore about 58 per cent. greater than the outer.

Instances of weakness, both transversely and tensilely, similar to those which are given in Table VII., are not unfrequent, and may occur, as before stated, in good-looking specimens of any species of timber: and this, again, serves to show that it would be unsafe to arrange the various parts of any construction according to the highest calculated strength of any timber to be employed.

Further tensile experiments were made on six specimens of British Oak saved from the pieces experimented upon, and referred to in Tables V. and VI. They appear

to be of better quality than those referred to in Table VII. The following are the results :—

TABLE XIV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the pieces broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
43	2 × 2 × 30	1003	35,560	8,890
44		1005	31,360	7,840
45		1002	33,600	8,400
46		905	33,040	8,260
47		720	24,640	6,160
48		725	23,520	5,880
Total . .	...	5360	181,720	45,430
Average .	...	893	30,287	7,571

Very little appears to be known of the amount of resistance offered by British Oak to a crushing force, when applied in the direction of its fibres. Some experiments of the kind have, it is true, been made, both in this and in other countries, but the results, as published, are far from being satisfactory, inasmuch as they vary to a great extent, as between author and author, and afford no reliable measure of the strain to which a pillar or column can be safely loaded.

The difficulty of carrying out these experiments is indeed so great, and withal so extremely tedious, that it is no matter of surprise more has not been done in this direction. I have, therefore, with the view of supplying a want long felt, availed myself of every opportunity to extend this important inquiry, by experimenting not only upon English Oak timber, but upon perhaps a greater variety of woods than has ever before been attempted.

The experiments on the vertical strength of British Oak are given in Tables XV. to XXII. inclusive.

TABLE XV.

Cubes of Unseasoned British Oak. Specific gravity, 966.
Vertical or crushing experiments.

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
49—52	2·750	7·000	20·000	33·750
53—56	2·500	8·000	19·375	31·875
57—60	2·000	9·500	20·125	33·125
61—64	2·500	8·500	19·625	32·875
65—68	2·250	8·125	20·500	33·125
69—72	2·375	9·250	20·125	33·500
Total . .	14·375	50·375	119·750	198·250
Average .	2·396	8·396	19·958	33·041
Do. per in.	2·396	2·099	2·217	2·064

TABLE XVI.

Cubes of Seasoned British Oak. Specific gravity, 740.
Vertical or crushing experiments.

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
73—76	3·750	13·000	28·750	50·875
77—80	3·500	12·500	29·750	50·125
81—84	3·375	14·375	29·125	49·875
85—88	3·625	14·000	28·500	50·625
89—92	3·500	13·875	29·125	49·875
93—96	3·625	14·125	28·875	51·125
Total . .	21·375	81·875	174·125	302·500
Average .	3·562	13·646	29·021	50·417
Do. per in.	3·562	3·411	3·225	3·151

TABLE XVII.

Vertical or Crushing Experiments on British Oak, with 4 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
97	2 × 2 × 1	740	13·500	3·375
98	,, ,, 2	,,	13·625	3·406
99	,, ,, 3	,,	13·875	3·469
100	,, ,, 4	,,	14·000	3·500
101	,, ,, 5	,,	15·750	3·937
102	,, ,, 6	,,	14·875	3·719
103	,, ,, 7	,,	14·750	3·687
104	,, ,, 8	,,	14·500	3·625
105	,, ,, 9	,,	15·000	3·750
106	,, ,, 10	,,	slipped	—
107	,, ,, 11	,,	14·750	3·687
108	,, ,, 12	720	13·750	3·437
109	,, ,, 18	,,	11·000	2·750
110	,, ,, 24	,,	10·500	2·625
111	,, ,, 30	734	9·750	2·437

NOTE.—Nos. 97 to 107 (inclusive) were cut from one piece of Timber, Nos. 108 to 110 were cut from another, and No. 111 from a third piece.

TABLE XVIII.

Vertical or Crushing Experiments on British Oak, with 9 square inches of base.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
112	3 × 3 × 8	912	15·50	1·722
113	,, ,, 9	981	16·125	1·792
114	,, ,, 10	960	16·00	1·777
115	,, ,, 11	943	16·50	1·833
116	,, ,, 12	928	14·75	1·639
117	,, ,, 13	901	13·50	1·500
118	,, ,, 14	891	14·00	1·555
119	,, ,, 15	883	15·00	1·666
120	,, ,, 16	900	15·00	1·666
121	,, ,, 17	768	23·50	2·611
122	,, ,, 18	789	22·00	2·444

NOTE.—Nos. 112 to 120 (inclusive) were cut from a piece of Oak timber that had been four years in store—it was not even then well seasoned; Nos. 121 and 122 were of better seasoned timber.

TABLE XIX.

Vertical or Crushing Experiments on British Oak, with 16 *square inches of base.*

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
123	4 × 4 × 15	958	25·50	1·600
124	,, ,, 16	972	25·25	1·578
125	,, ,, 17	934	27·00	1·687
126	,, ,, 18	930	27·50	1·719
127	,, ,, 19	932	28·25	1·762
128	,, ,, 20	972	28·25	1·762
129	,, ,, 21	946	28·00	1·750
130	,, ,, 22	932	26·00	1·625
131	,, ,, 23	921	23·50	1·470
132	,, ,, 24	1·003	30·00	1·875

TABLE XX.

Vertical or Crushing Experiments on British Oak, with 9 *square inches of base.*

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
133	3 × 3 × 8	696	25·25	2·805
134	,, ,, 9	597	21·00	2·333
135	,, ,, 10	742	20·25	2·250

NOTE.—These were respectively Nos. 115, 118, and 121 of Table XVIII., shortened, and further seasoned.

TABLE XXI.

Vertical or Crushing Experiments on British Oak, with 16 *square inches of base.*

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
136	4 × 4 × 10	713	34·875	2·179
137	,, ,, 11	658	33·750	2·110
138	,, ,, 12	639	32·000	2·000
139	,, ,, 13	665	29·500	1·843
140	,, ,, 14	752	31·250	1·953
141	,, ,, 15	742	28·500	1·781
142	,, ,, 16	688	40·750	2·517

NOTE.—These were respectively Nos. 132, 123, 125, 124, 127, 129, and 130 of Table XIX., shortened after the first experiments upon them, and further seasoned before the second trial.

TABLE XXII.

Vertical or Crushing Experiments on British Oak; sundry scantlings.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Crushed with	Do. on the square inch.
	Inches.		Tons.	Tons.
143	3 × 3 × 2	820	32·125	3·569
144	4 × 4 × 2	822	53·125	3·320
145	6 × 6 × 12	864	131·000	3·640
146	,, ,, 18	926	154·000	4·277
147	,, ,, 24	822	122·200	3·394
148	,, ,, 36	888	122·200	3·394
149	9 × 9 × 12	1·024	223·600	2·760
150	9′ × 9′ × 15	918	247·800	2·898
151	,, ,, 18	889	244·800	2·860
152	,, ,, 21	883	247·000	2·887
153	9′ × 10′ × 15	904	397·000	4·175
154	10′ × 11 × 18	794	307·000	2·722
155	,, ,, 21	819	327·800	2·907
156	9′ × 10′ × 24	905	307·000	3·239

In these tables are recorded the results of 108 experiments on the crushing strains applied to specimens of English Oak timber, varying from small pieces with only 1 inch of base, and 1 inch in height, carrying 7,978 lbs., to larger pieces with 110 inches of base, and 21 inches in height, carrying 734,272 lbs., or 327 tons 16 cwt., before breaking. The intermediate sizes include some pieces with 36 inches of base and 36 inches in height, this being the greatest length upon which I have been able to bring the crushing force to bear.

It is to be regretted that these experiments could only be carried on with pieces of inconsiderable length, owing to the difficulty experienced in keeping the centres perfectly straight with the line of pressure. Still, enough has, I hope, been done to afford a fair guide for determining the scantlings for pillars to beams, &c., although, perhaps, there is not even yet sufficient data to construct a formula upon.

M. Rondelet ascertained that it took a force of 5,000 to 6,000 lbs. to crush a piece of Oak having 1 inch of base; and Mr. Rennie gives 3,860 lbs. as the force required to crush a similar piece 1 inch in height. These two statements vary considerably from each other, and also from my own experience, inasmuch as I found it required a force of 7,978 lbs., or 3·562 tons weight, to crush a 1-inch cube of seasoned Oak; *vide* Table XVI.

In a trial, however, of six pieces of unseasoned Oak of the same dimensions, it was found that it took upon an average only 5,367 lbs., or 2·396 tons — one piece requiring only 4,480 lbs., or 2 tons, to crush it; *vide* Table XV.

The experiments upon seasoned cubes of Oak, of 2, 3, and 4 inches (Table XVI.) show that the force re-

quired to crush them was, severally, 7,640 lbs., 7,224 lbs., and 7,058 lbs., per square inch of base, which, if compared with 7,978 lbs. on the one-inch cube of the same seasoned wood, shows an apparent diminution of strength in each of the next larger sizes; the average force required to crush the complete parcel of four sets of cubes being 7,475 lbs. The average strength of the unseasoned pieces of the same dimensions only 4,915 lbs. to the square inch of base.

In the experiments (Table XVII.) on a set of fifteen specimens, each 2 × 2 inches, and severally varying only 1 inch in length from 1 to 12 inches, and then by 6 inches, until a length of 30 inches was obtained, it was found that the piece 5 inches in length bore the maximum pressure of 8,820 lbs., or 3·937 tons on the square inch, the resisting power of each of the others being less, while the piece of 24 inches was crushed by about two-thirds the strain of that of 5 inches in length.

From this it would appear that the proper proportion of sectional area to length for this description of timber is as about 4 : 5 ; or, in other words, the superficial area of the base in inches should not be less than four-fifths the length of the pillar or column in inches.

Thus, if it were required to ascertain the scantling for an Oak pillar, 144 inches in length, to ensure its carrying the maximum of strain, we should have $\sqrt{\frac{144\times4}{5}} = 10{\cdot}73$ inches for the side of that pillar, and according to the ascertained strength of our specimen, 5 inches in length, this would be capable of bearing a weight of 453 tons. Even if we observe the rule, recommended by many authorities, of only loading to one-fourth of the calculated strength, we may still consider it equal to the strain of 113 tons, while a pillar of Riga

Fir of the same dimensions, as shown in subsequent Tables, might be loaded to 67 tons.

As before stated, I have applied this description of test to a great variety of woods, and it has enabled me to ascertain with tolerable accuracy the amount of strain they will each bear to the square inch of base. The general result of the trials with gradation of lengths confirms, in some degree, the theory of a four-fifths proportion of base to length, and shows it to be at least approximately correct. Therefore, with this data for our guidance, aided by a little practical judgment, there should be no difficulty in determining the scantlings of props and supports for all ordinary purposes.

There is yet another description of test to be noticed, namely, that for ascertaining the elongation of the fibres under certain strains. The experiment was made in one of the royal dockyards upon two pieces of English Oak, each $2 \times 2 \times 48$ inches, and very carefully conducted—note being taken of the elongation in a length of 3 feet; the mean results were found to be as follows, viz. :—

TABLE XXIII.

With the weight of	2	3	4	5	6	7	tons.
The elongation was	·0	·03125	·04617	·07812	·1250	·15625	ins.
With the weight of	8	9	10	11	12	...	tons.
The elongation was	·19375	·23437	·2500	·2500	·3125	...	ins.

CHAPTER XI.

ON THE FELLING OF OAK IN SPRING AND WINTER.

THE bark of the Oak tree contains a substance called tannin, which is of considerable value, and is used in the preparation of leather. Therefore, in order to secure this tannin in its greatest quantity, it is the practice to fell, or cut down, the trees in the spring of the year, when the sap is rising. Under other circumstances, the trees would have been cut in the winter, while the sap was down and in a quiescent state—a period which has been almost universally recognised as the best for felling, as it is considered to ensure a better quality, and to be conducive to the greater durability of the timber. The value of the bark, however, generally overrides this consideration, since, although the weight in proportion to the contents of the timber will vary according to circumstances of growth, it is always thought profitable to save it, and, viewed under the commercial aspect, it is not likely to be disregarded.

The quantity of tannin contained in the bark of the Oak, as ascertained by Sir Humphry Davy, varies as follows, viz.: In Coppice Oak it is 32; middle sized, 29 and Oak cut in the autumn, 21 per cent.

The timber and bark merchants variously estimate the quantity of bark to the contents of the timber; and no doubt there is a very considerable difference in the

weight afforded by trees of equal ages, whether grown in forests or in open situations. Mr. Monteith states, in his "Planter's Guide," that—

An Oak 40 years old yields, for every cubic foot of timber ... ... 9 lbs. to 12 lbs. of bark.
And if 80 to 100 years old yields, for every cubic foot of timber ... ... 10 lbs. to 16 lbs. ,,

The question of the propriety of felling in the winter in preference to any other season is of considerable importance, and its bearing upon the durability or otherwise of the timber may be gathered from the following particulars, taken from a "Treatise on Dry Rot," by Ambrose Bowden. He states that—

"The 'Sovereign of the Seas,' built at Woolwich in 1635, was constructed of timber barked in the spring and felled in the succeeding winter, a strong conviction existing that such timber was superior to any other in point of durability. Forty-seven years later this ship was pulled to pieces and rebuilt, and the greater part of the materials were found to be in sufficiently good condition for re-employment.

"The 'Royal William,' built at Portsmouth in 1715 to 1719, after being slightly repaired at three different times, was finally taken to pieces in August, 1813, after a service of ninety-four years. The extreme durability of this ship attracted much attention at the time, and it was believed that, having been built in close proximity to the New Forest, only winter-felled timber had been used in her construction. This is said to be borne out by the fact that the authorities at Portsmouth, about 1717 or 1718, offered, as an encouragement for the delivery of winter-felled Oak timber to that yard, an

addition of* £5 per cent. to the contractor to compensate him for the loss of the bark. The state of the materials when the ship was taken to pieces confirmed the conjecture which had been then formed, as the iron fastenings, above the water-line, were in general good, proving the absence of acrid juices in the timber.

"In the year 1755, Mr. Barnard, of Deptford, contracted to build a sixty-gun ship, named the 'Achilles,' for His Majesty's service. She was completed in 1757, and taken to pieces in 1784. It was not known that any peculiar circumstances attended the construction of this ship, until Mr. Barnard was summoned to attend a Committee appointed by the House of Commons, in March, 1771, to consider how His Majesty's navy might be better supplied with timber. He then gave it as his opinion that the method to be observed in felling timber should be by barking in the spring, and not to fell it until the succeeding winter, and added that he built the 'Achilles,' man-of-war, in 1757, of timber felled in that manner.

"The 'Montague,' launched in 1779, was built of winter-felled timber, and its superiority is forcibly attested by the fact that she had only one frame-timber shifted, from the time she was built up to 1803, when she was repaired. Mention is also made of this ship being in active service and in good condition in 1815; that is, thirty-six years after she was launched. It was thought there was a striking coincidence between the durability of this ship and that of the 'Royal William,'

* A much higher premium than £5 per cent. in addition to the contract price of spring-felled Oak timber was offered and paid by the Government a few years since for winter-felled Oak, without, however, being able to obtain more than a fraction of the quantity required for the royal dockyards.

affording a strong presumption that they were both built on the same principles.

"The 'Hawke' sloop was built in 1793, one half of timber barked in the spring and felled in the winter, and the other half of timber felled at the usual time in spring. Ten years later she was in such a general state of decay that she was taken to pieces, no difference being then observable in the condition of her several timbers."

"At first view," Mr. Bowden observes, "this experiment appears to decide the fate of the system ; but it must be remarked that the timber was barked standing in the spring of 1787, and not felled until the autumn of 1790, a period of three and a half years ; and further, that if we were to inquire into the probable duration of such timber, we might discover, perhaps, that it is in an inverse ratio to the time the trees may stand after being barked ; and therefore, this ship was in precisely the same state at the end of ten years as we might reasonably have expected."

CHAPTER XII.

BRITISH OAK.—CONTRACT SPECIFICATION.

THE British Oak tree affords logs that meet the following specification for the navy contracts, viz. :—

Timber sided ; or if rough, that will side—

20 inches and upwards,		the shortest length being	26	feet.
20½ ,,	to 19 inches,	,,	24	,,
18½ ,,	,, 17 ,,	,,	20	,,
16½ ,,	,, 15 ,,	,,	16	,,
14½ ,,	,, 13 ,,	,,	14	,,
12½ ,,	,, 11 ,,	,,	12	,,
10½ ,,	,, 9 ,,	,,	10	,,

the quantities of each class or siding varying according to the requirements of the dockyards.

For the rough timber (Fig. 16, *a* and *b*) it is generally agreed that the price is to be, for each log measuring—

250 cub. ft. and upwards,		rough contents,	℔ load of 50 cub. ft.	£
249 ,,	to 200 cub. ft.	,,	,,	
199 ,,	,, 150 ,,	,,	,,	
149 ,,	,, 100 ,,	,,	,,	
99 ,,	,, 50 ,,	,,	,,	
49 ,,	,, 25 ,,	,,	,,	
Under	25 ,,	,,	,,	

the conditions being that the measurement of rough timber for payment is to be regulated by the stops or joggles. Every piece to be measured for contents by calliper measurement, as far as the spire will hold 12 inches in diameter. No tops to be received, except the spire and such other top or limb as may be grown on the main piece, of a substance and length to admit of being converted with it. Such other top or limb will be measured for contents as far as it will hold

FIG. 16*a*.

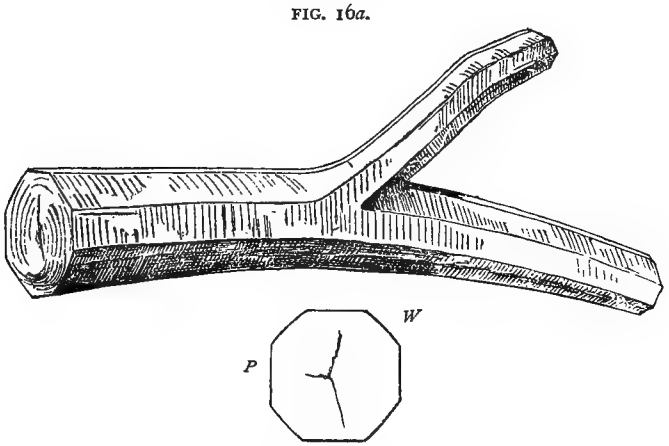

FIG. 16*b*.

12 inches in diameter. If, however, the professional officers of the yards are of opinion that the conversion of the main piece will be improved thereby, tops, including the spire, will be measured for contents as far as they will hold 9 inches in diameter; but, in such case, two-thirds only of the contents below 12 inches in diameter will be added to the other contents of the piece for payment. All the rough timber to be so hewn or squared that no part of the surface or square

shall be less than one-fourth of the diameter of the piece.

For the sided timber (Fig. 17)*, it is also agreed that the price is to be, for each log measuring—

120 cub. ft. and upwards,			sided contents,	₱ load of 50 cub. ft.	£
119	,,	to 100 ft.	,,	,,	
99	,,	,, 80 ,,	,,	,,	
79	,,	,, 60 ,,	,,	,,	
59	,,	,, 40 ,,	,,	,,	
39	,,	,, 20 ,,	,,	,,	
	Under 20	,,	,,	,,	

the conditions being that in computing the measurement

FIG. 17*a*.

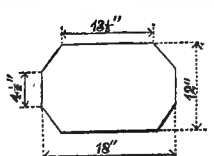

FIG. 17*b*.

for payment of sided timber, no quarter-inches to be allowed in the sidings. All the timber to be so sided that, between the wanes,† at half the length of the piece, there shall not be less than the siding with one-eighth

* It has been found in practice that a fairly grown cylindrically-shaped British Oak tree of

30 inches calliper will yield sided timber of about 21 inches.
24 ,, ,, ,, ,, 18½ ,,
18 ,, ,, ,, ,, 12½ ,,

and that generally about two-thirds of the calliper of the rough tree is the siding to be obtained from it.

† Wane is the natural rounded edge of the log, *W* Fig. 16*b*.

added thereto; to be fairly sided from end to end, parallel, and to be measured for contents as far as it holds, at the top end, on each side, between the wanes, three-fourths of the siding of the piece. The pane* at the top is to determine the length of the piece; but if the length of the sides be not equal, the mean is to be taken. The timber to be so hewn upon the moulding edges that the surface of the square shall not be less than one-fourth the diameter of the piece. The timber to be measured for contents at the middle of the length,

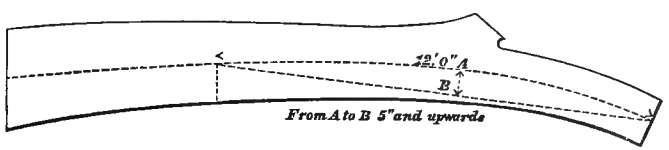

FIG. 18.

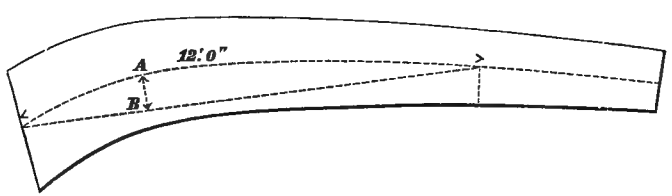

FIG. 19.

when fairly grown from end to end, but if otherwise, it will be regulated by the stops or joggles. Such timber as has length beyond the prescribed proportion of pane, being compass timber, and the additional length aiding the conversion, or such as shall be *bonâ fide* convertible for a beam piece, to be received at the discretion of the officers, who are to determine the length; two-thirds of the additional length to be measured for the cubic contents.

* Pane is the hewn or sawn surface of the log, *P* Fig. 16*b*.

Premium prices were until lately paid for logs suitable for the stems and stern-posts, and also for logs having compass form suitable for the frames of ships (Figs. 18 and 19); but this is no longer necessary, as the supply is fully equal to the demand for these particular services.

It is, of course, understood that the wants of the private trade are as well met as those of the royal navy, nothing being required by the navy specification other than is afforded by the ordinary growth of the tree.

Thick-stuff and plank is supplied to the navy according to the following specification :—

Thickness.	Shortest length.	To average in length at least	Breadth between the sap at 24 ft.	To be measured as far as it holds between the sap.	Remarks.
Inches.	Feet.	Feet.	Inches.	Inches.	
10	24	28	11	8	Thick stuff, 4½ in. and upwards, is measured in cubic feet.
9			,,	,,	
8			,,	,,	
7			9	7	
6			,,	,,	
5			,,	,,	
4½			,,	,,	
4			8	6	Plank, 4 to 2 in. inclusive, is measured in superficial feet of its thickness.
3½			,,	,,	
3	20		7*	,,	
2½			,,	,,	
2			,,	,,	

* At 20 feet.

All the thick-stuff and plank to be cut straight, or nearly so, and of parallel thickness, and to be measured for breadth at the middle, or half the length, taking in half the wanes, provided the breadth, clear of sap, is within two inches of the breadth at which it is to be received; but no thick-stuff the breadth of which in

the middle is less than 11 inches or more than 18 inches, and no plank of 4, 3½, and 3 inches, less than 9 inches or more than 15 inches, and none of 2½ and 2 inches, less than 8 or more than 15 inches, clear of sap at half the length, is to be received.

All the timber, thick-stuff, and plank to be fresh-cut, good, sound, merchantable, well-conditioned, and in every respect fit for Her Majesty's service.

CHAPTER XIII.

THE FRENCH OAK TREE (*Quercus*).

THE Oak timber of the north-western provinces of France, and especially of Brittany and Normandy, so closely resembles British Oak timber in colour, quality, texture, and general characteristics, that a description of one will as nearly as possible serve for the other. It is, therefore, I think, fairly entitled to the first notice after that which has been adopted as our standard.

The French Government until quite recently claimed the right of first selection of this description of timber, and drew nearly all their supplies from the western districts, for the use of their own dockyards, the landed proprietors and merchants not being free to offer it on the market until the full requirements of the French navy were met. Consequently, but little, if any, of good quality was left for exportation after the demands of the private trade of that country were satisfied.

The first sample shipped to the London market after the relaxation of the French laws bearing upon it (about the year 1860) enabled the British Government to give it a trial in ship-building; and as this proved to be satisfactory, a contract was soon after made with a London merchant for a supply to the several dockyards in England.

French Oak, until about the time I am speaking of, was looked upon with some disfavour in this country, and thought to be generally inferior in quality to the British Oak; but this opinion was probably formed from very unfavourable specimens, there being certain localities in France, as there are in most other countries, where the trees do not attain any degree of excellence, and also from the fact that the best timber had been first selected and retained by the French Government.

The Oak timber, however, of the north-west provinces of France is generally of very good quality, and experience in the employment of it in ship-building proves it to be an excellent substitute for that of British produce. It is a very remarkable fact that, of all the supplies sent to the several royal dockyards, the only complaint ever urged against it was that it had not been hewn in accordance with English practice as applied to "sided timber," and that the loss in conversion would be greater in consequence. This, however, was only imaginary, as the converters at Woolwich proved that there was little to object to on that score, their returns for the three years ending in 1863 making the difference in the loss per cent. in the conversion of the French, as compared with that of British Oak, to be quite insignificant, the figures actually showing that the loss on the French Oak was 47·3 per cent., and on the

British 47·4 per cent.; the yield was therefore as nearly as possible the same in both cases.*

Figs. 20*a* and 20*b* show the method of hewing the French Oak, whereby all the square wood that could be obtained is preserved, by simply following the natural taper or growth of tree, and, by so doing, there can be little, if any, disadvantage, since, the measurements being taken, as in English timber, at the middle, or half the length of the log, the buyer would receive and pay for the correct quantity contained in it.

FIG. 20*a*.

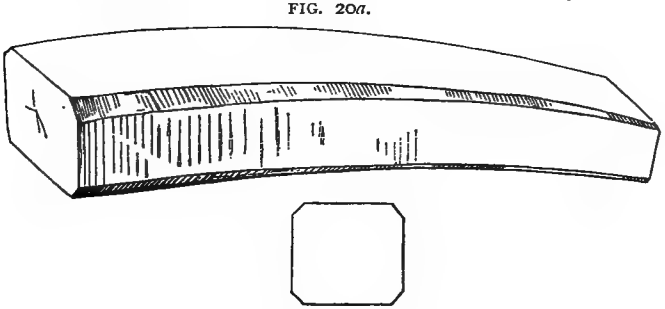

FIG. 20*b*.

The error in estimating its worth at the dockyards was one of those things to which professional and practical men are occasionally liable, when they have long been accustomed to a particular form or object, and are unwilling to see in any change that an advantage may sometimes be gained by its adoption.

About eighty loads of French Oak timber of compass form, that is, of pieces having at least 5 inches bend in

* Since the foregoing was prepared I have referred to recent Blue Books, and find that the conversions done in French Oak at the royal dockyards are all favourable, the loss upon the French being less than that on the English Oak by about 6 per cent.

a length of 12 feet, were worked into the frame of the "Pallas," built at Woolwich Dockyard in 1863, and when the timbers were examined after they had been dressed and trimmed to a fairness fit to receive the planking, it was very difficult to distinguish the French from the English Oak with which it was mixed.

A considerable portion of this French Oak timber, after lying in the several royal dockyards for about ten years, seasoning, some of it in the open, and some in sheds protected from the weather, when surveyed was found to be in better condition than the English Oak of the same dates of receipt, which had been kept in stacks similarly placed for preservation.

No better evidence than this can be needed to prove that the French Oak is equal to the English in point of durability, and there is yet to be carried to its credit the fact that experiments prove it to be equally strong, tough, and elastic. It is also in its favour that it shrinks only moderately in seasoning, and rends or splits somewhat less than the English Oak during that process.

That it is suitable and fit for all the purposes to which English Oak is applied, in ship-building or other works of construction, there is no reason to doubt; and, except that the timber procured from the north-west of France is generally smaller, shorter, and has a more tapering form than the English Oak timber tree, there is no appreciable difference in them, and in a manufactured state the cleverest expert could not tell one from the other.

The experiments made on French Oak (Tables XXIV., XXV., and XXVI.) are perhaps sufficient to show its relative merits as compared with our standard. French is classed with English Oak at Lloyd's, for employment in ship-building.

TABLE XXIV.—FRENCH OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·50	·00	4·35	720	966	745	180·00
2	1·35	·05	7·00	930	977	952	232·50
3	1·50	·05	6·05	901	983	916	225·25
4	1·55	·10	5·50	895	992	902	223·75
5	1·65	·00	7·00	915	979	934	228·75
6	1·35	·05	6·10	904	962	939	226·00
Total .	8·90	·25	36·00	5,265	5859	5388	1316·25
Average	1·483	·041	6·00	877·5	976·5	898	219·375
The average of six other specimens, of equal quality to the above, gave—							
7—12	1·583	·125	7·583	831·	1082	768	207·75
The mean of the whole—							
	1·533	·083	6·791	854	1029·5	833	213·562

REMARKS.—All the specimens broke with a fibrous fracture fully 10 inches in length.

TABLE XXV.

Tensile Experiments.

Number of the specimen.	Dimension of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
13	2 × 2 × 30	966	21,280	5,320
14		979	40,040	10,010
15		983	39,208	9,802
16		962	27,432	6,858
17		977	33,460	8,365
18		992	33,040	8,260
Total. .	...	5859	194,460	48,615
Average.	...	976·5	32,410	8,102

TABLE XXVI.

Vertical Experiments on cubes of 2 inches.

No. 19.	No. 20.	No. 21.	No. 22.	No. 23.	No. 24.	Total tons.	Average tons.
Crushed with	Crushed with	Crushed with	Crushed with	Crushed with	Crushed with		
Tons. 12·500	Tons. 14·000	Tons. 14·125	Tons. 14·875	Tons. 14·750	Tons. 14·875	85·125	14·187
*3·125	3·500	3·531	3·719	3·687	3·719	14·187	3·547

* On 1 square inch.

REMARKS.—These cubes were in about the same seasoned condition as the English Oak, Table XVI.

$$E = 622720. \qquad S = 2242.$$

CHAPTER XIV.

THE ITALIAN OAK TREE (*Quercus*).

THERE are several varieties of very valuable Oak trees spread over the whole length of the Italian peninsula, the island of Sicily, and also in the island of Sardinia, which in form and quality differ but slightly one from the other.

Botanists might say they were all of erect growth, yet they very rarely attain a perfectly upright position, as, owing to their naturally curved and crooked form of stem, they must necessarily be a little, more or less, inclined to the horizon. They appear generally to attain at least moderate dimensions; but, judging from those imported into this country, their best specimens are inferior in size to many of our British Oak trees.

The following varieties of Italian Oak, viz., the *Quercus Robur*, *Q. montella*, *Q. Tuscana*, *Q. pyrenaica*, *Q. vera*, *Q. Ischia*, and the *Q. montana*, are the best in quality. There are also the *Q. cerro*, *Q. Æsculus*, *Q. farina*, and one or two others which are not generally thought to be quite equal to those first mentioned. They may, nevertheless, occasionally compare favourably with them, especially when they are found at a moderate elevation, or on the mountain sides.

The wood of the Italian Oak is brown in colour,

hard, horny, tough, strong, less elastic and slightly heavier than the English Oak, and is, on account of its extreme hardness, more difficult to work. In seasoning it is very apt to split and leave deep shakes on the exterior of the log, which are detrimental to its value for general purposes; but, viewed as to its form and properties, it is employed in preference to most other Oaks for the frame of a ship. It may also be used in any work of construction where strength and durability are important, if care be taken to protect it, by planks or otherwise, from exposure.

Owing to its characteristic defect of shakes in seasoning, the Italian Oak is unfit for conversion into planks, or boards, or into almost any small scantlings; and its introduction into this country (about the year 1820) was not with the view to its general employment, but solely to supplement the supply of British Oak timber, which was then scarce, and seemed likely to be insufficient in quantity to meet the growing demands for it, especially for the framing of our ships of war. For this particular purpose, where it is generally used in bulk to nearly the full growth of the tree, preference may even be given to it over English Oak.

Of the different kinds of Italian Oak supplied to the royal dockyards, the Tuscan, Neapolitan, and Sicilian are the hardest and most horny in texture, and, when thoroughly seasoned, by far the most difficult to work; while the Modena, Roman, and Sardinian are what the workmen call milder in character—that is to say, they are easier to work, and a little less hard than the former.

The Modena and Sardinian also yield an easier curved form of timber than the other kinds, and do not split to the same extent in seasoning; they are all, however, very much of the same strong character, and it

is a fact worth mentioning, as showing the unusual hardness of this kind of timber, when well seasoned, that I have known many sawyers, when only entered temporarily in the dockyards for some pressing work to be done, leave rather than be employed in cutting this timber.

Very large supplies of this description of timber were sent to H.M. dockyards during the years 1860 to 1863, the greater part of it having been contracted for just prior to the introduction of iron ships for war purposes. But the wooden fleet having been almost superseded by the time it was delivered, a considerable quantity of it is still upon hand (1875); yet even now, although much of it has been from ten to twelve years in store, it is for the most part in a good state of preservation. The French Government for a long time drew upon the Italian states for considerable quantities of this Oak for the use of their dockyards, and were often competing with our own for the possession of it; thus, until quite recently, Italian Oak was an important and valuable article to the two chief naval powers of the world.

In the employment of this wood very few defects are found, and no better evidence is necessary to show that great care is taken of it during its growth. It has both the star and the cup shake, but neither of these defects are very common in the Oaks grown upon the mainland or in the island of Sardinia. The Sicilian Oaks have, however, rather extensive cup-shake defects.

It was stipulated in the conditions of the navy contracts that about three-fourths of all the Italian Oak timber should be of compass form—that is to say, to qualify it as such, it must have at least five inches of curve in twelve feet, taken in any part of the length of the log; and this proportion was almost invariably

obtained, while many of the logs which did not pass for compass had generally more or less curve, and a straight log was quite the exception.

The specification under which Italian Oak (Fig. 21, *a* and *b*) was received stood as follows, viz.:—

	Price per Load of 50 feet. £ s. d.
Pieces containing each 30 feet and upwards cube	
,, ,, ,, 20 feet and under 30 feet	
,, ,, ,, 14 feet and under 20 feet	
Pieces under 14 feet contents, sided 9 to 11½ inches, inclusive, and not less than 10 feet long...	
Pieces under 14 feet contents, sided 7 to 8½ inches, inclusive, and not less than 8 feet long	

FIG. 21*a*.

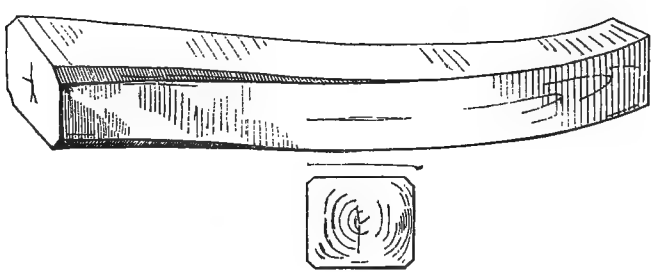

FIG. 21*b*.

All the timber to be winter-felled. Pieces sided 7 to 8½ inches, inclusive, to have at least 8 inches curvature in 8 feet in some part of its length.

The straight timber, excepting that sided 9 to 11½ inches, inclusive, to be 20 feet and upwards in length . . . . and both compass and straight timber to measure in the middle between the wanes, or to have pane at that place, not less than the siding of the piece with one-eighth part added thereto, and the pane at the top end not to be less than three-fourths the siding of the piece.

All the timber to be fairly tapered from end to end, and not to have

more wane at any part than 4 inches on the two wanes taken together; or, if there is no wane on one edge or angle, and it is only on the other edge or angle, that wane is not to exceed 4 inches.

The compass timber to be sided from 7 to 20 inches, inclusive, and no part thereof, except of from 7 to 11½ inches sided, to be less than 13 feet in length.

The transverse strength of Italian Oak is shown in Tables XXVII., XXIX., and XXX., and the vertical strength in Tables XXVIII. and XXXI.; but there are fewer experiments on these than on most other woods, owing to the difficulty that was found in obtaining a length of seven feet with a clean straight grain for testing.

TABLE XXVII.—ITALIAN OR TUSCAN OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	4·50	·15	7·25	766	1011	758	191·50
2	3·75	·15	9·25	659	1094	602	164·75
3	2·15	·00	7·35	625	985	635	156·25
4	4·65	·20	6·85	906	1018	889	226·50
5	4·50	·15	8·55	777	1025	758	194·25
6	3·00	·15	6·75	813	1110	732	203·25
Total .	22·55	·80	46·00	4546	6243	4374	1136·50
Average	3·76	·133	7·66	757·66	1040·5	729	189·41

REMARKS.—All the specimens broke with fibrous fractures, 10 to 16 inches in length.

TABLE XXVIII.—ITALIAN OR TUSCAN OAK.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
10·00	9·75	9·5	9·75	10·00	9·5	58·5	9·75
*2·50	2·437	2·375	2·437	2·50	2·375	9·75	2·437
* On 1 square inch.							

$E = 248950.$ $S = 1989.$

TABLE XXIX.—ITALIAN OR MODENA OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·25	·05	5·65	848	1130	750	212·00
2	2·30	·05	6·70	787	1103	713	196·75
3	2·25	·05	6·15	881	1121	786	220·25
4	2·70	·15	7·00	823	1060	776	205·75
5	2·25	·10	6·25	859	1092	787	214·75
6	2·25	·05	6·00	859	1150	747	214·75
Total .	14·00	·45	37·75	5057	6656	4559	1264·25
Average	2·33	·075	6·291	842·83	1109·3	7598·3	210·71

REMARKS.—Nos. 1, 5, and 6 broke with fractures slightly scarf-shaped; 2, 3, and 4 had long fibrous fractures.

$E = 400420.$ $S = 2212.$

TABLE XXX.—SARDINIAN OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·65	·05	5·75	765	1002	763	191·25
2	2·75	·10	5·65	659	1030	639	164·75
3	3·15	·15	4·85	630	1025	614	157·50
4	2·25	·15	8·00	906	943	961	226·50
5	2·50	·15	8·25	776	973	899	194·00
6	2·35	·15	6·50	812	970	838	203·00
Total .	15·65	·75	39·00	4,548	5943	4714	1137·00
Average	2·608	·125	6·5	758	990·5	785·66	189·5

REMARKS.—Nos. 1, 2, and 3 broke rather short to 1-5th the depth, and had about 12 inches length of fracture under it. 4, 5, and 6 had 13 inches length of fibrous fracture.

TABLE XXXI.—SARDINIAN OAK.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
10·00	10·125	10·625	10·750	10·000	11·000	62·500	10·416
*2·5	2·531	2·656	2·687	2·500	2·750	10·416	2·604
* On 1 square inch.							

$E = 363450.$ $S = 1990.$

CHAPTER XV.

THE DANTZIC OAK TREE (*Quercus*).

THIS Oak derives its name from the port of shipment, but is chiefly the produce of the Polish forests, whence the bulk of it is brought down the river Vistula to Dantzic; small quantities are also sent into the ports of Memel and Stettin by other sources.

There is a considerable quantity of Oak timber exported from these three places in logs, varying from 18 to 30 feet in length, and from 10 to 16 inches square, and also planks 24 feet and upwards in length, averaging about 32 feet, the breadth being from 9 to 15 inches, and the thickness varying from 2 to 8 inches. Large quantities of staves, roughly cleft from the tree, are also exported in various sizes, suitable for the manufacture of every description of cask or barrel.

The Dantzic-Polish or Prussian Oak timber is obtained from a tree of straight growth. It is brown in colour, of moderate strength and hardness, rather porous, and has the medullary rays bright and sufficiently

distinct to qualify it in some instances for wainscot purposes. It is of fair durability, and is largely used in the construction of the mercantile ships of this country, but only sparingly for our ships of war, except for their decks, for which purpose it is regarded as a spécialité, as it stands well the wear and tear of the gun carriages. For planking it is much esteemed, as the grain is straight, clean, and almost free from knots. Further, it is so pliable and elastic, when boiled or heated by steam, that it may be bent into the most difficult of curved forms without showing any sign of fracture.

This description of timber is carefully classified by the merchants, and divided into crown and crown brack qualities, the former being selected from trees of the fairest growth, clean in the grain, and generally free from every kind of coarseness and defect, while the crown brack includes the short and irregularly grown trees, and all those of a rough, coarse, and knotty character.

With the Oak planks they are more particular than with the timber, and endeavour to secure uniformity in their arrangement by employing a sworn bracker to make the classification. Thus the planks of each thickness are sorted into first and second qualities, or rather into crown and crown brack qualities as understood in the trade, and are respectively distinguished by the mark W on the best, and WW on the second best, plainly rased upon the side of the plank. Those of the crown quality are selected from the finest and fairest grown trees only, the crown brack being made up of planks produced from trees of less regular growth, including the coarse and sometimes faulty pieces. The com-

mercial values of the two bracks vary both in the timber, and in the plank, in about the proportion of three to two.

In civil architecture, the Dantzic Oak may be used with advantage for a great variety of purposes, as it stands well, shrinks only moderately, and without splitting much in seasoning.

The Navy contracts for Dantzic Oak do not include square timber, but thick-stuff of 7 to 4½ inches, and plank of 4 to 2 inches only, which are received under the following specification :—

The Dantzic Oak thick-stuff and plank to meet at 32 feet, and none to be shorter than 24 feet; and to be from 10 to 13 inches broad, averaging 11 inches clear of sap. The whole to be fresh, clean, free from defective wanes, cut regular, square-edged, and straight; the breadth for measurement to be taken clear of sap at the middle of the length; 67 per cent. of each thickness to be of first or crown quality, and the remainder of second or crown brack quality.

Tables XXXII. and XXXIII. show that the Dantzic Oak, when tested transversely, or tensilely, is of moderate strength; and, according to Table XXXIV., when tested for the vertical or crushing strain, it proves to be strong, and compares favourably with the British Oak.

TABLE XXXII.—DANTZIC OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	4·30	·15	5·25	474	850	558	118·50
2	4·35	·25	5·25	466	812	573	116·50
3	5·55	·30	6·85	449	817	549	112·25
4	5·75	·25	7·00	456	768	592	114·00
5	5·20	·25	7·85	508	897	566	127·00
6	4·85	·25	6·55	488	872	559	122·00
Total .	30·00	1·45	38·75	2,841	5016	3397	710·25
Average	5·00	·24	6·458	473·5	836	566·16	118·37

REMARKS.—All the specimens broke rather short.

TABLE XXXIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	812	13,444	3,361
8		817	14,276	3,569
9		850	17,920	4,480
10		872	21,840	5,460
Total . .	...	3351	67,480	16,870
Average .	...	838	16,870	4,217

TABLE XXXIV.

Vertical or Crushing Experiments.

Nos.	Dimensions.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Total tons.	Average tons.	Ditto on 1 square inch.
11—16	1″ × 1″ × 1″	3·575	3·875	3·625	3·750	3·9375	3·875	22·6375	3·7729	3·773
17—22	2″ × 2″ × 2″	13·500	13·250	13·375	13·750	13·8750	13·250	81·0000	13·5000	3·375
23	3″ × 3″ × 3″	28·500	...	...	...	...	...	...	28·5000	3·166
24	4″ × 4″ × 4″	49·000	...	...	...	...	...	...	49·0000	3·062
25—28	2″ × 2″ × 1″ 2″ 3″ 4″	14·125	13·500	14·000	14·250	...	...	55·875	13·9690	3·492

TABLE XXXV.

Experiments on specimens of Dantzic Oak.

Nos. 29, 30, and 31, to ascertain the elongation of the fibres in a length of 3 feet, taken under various strains, the dimensions of the pieces being 2 by 2 by 48 inches.

3 Tons.	4 Tons.	5 Tons.	6 Tons.	7 Tons.	8 Tons.	9 Tons.	10 Tons.	11 Tons.	12 Tons.	13 Tons.	Elongation preceding rupture.	Breaking strain in tons.
Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	
1/32	1/16	3/32	2/16	5/32	3/16	7/32	4/16	4/16	...	...	4/16	11·25
1/32	1/16	2/32	2/16	5/32	3/16	7/32	8/16	4/16	4/16	4/16	4/16	13·25
1/32	1/16	2/16	3/16	4/16	...	...	...	...	...	...	4/16	7·50
Mean ·0312	·062	·0937	·146	·187	·218	·25	·25	·25	·25	·25	·25	10·666

E = 189680. S = 1243.

CHAPTER XVI.

THE RIGA OAK TREE (*Quercus*).

THIS Oak, like the preceding, takes its name from the port of shipment, and is the produce of a tree found some distance in the interior of Russia, whence it is brought by the River Düna to Riga. Its dimensions are only moderate, and, as it is far from being abundant, very little ever reaches this country, except in the form of wainscot logs, of which there were imported into the London market, 20,500 pieces in 1874, 9,400 in 1873, 8,100 in 1872, 7,700 in 1871, and about 10,400 in the previous year.

It is characteristic of this Oak timber, that the medullary rays are very numerous and more distinctly marked than is the case with the Dantzic Oak; but, otherwise, the wood is in colour, texture, fineness of grain, and general appearance, very much the same, as is also its strength and specific gravity. There is no reason, therefore, to doubt its fitness for employment in civil architecture, or for general purposes, but it is chiefly shipped to this country to meet the demand for ornamental work, and for the manufacture of furniture.

To prepare it for the London market, the butt

lengths of the tree are slightly hewn upon two opposite sides, and then sawn down the middle; the logs have thus a nearly semicircular form (Fig. 22), the average contents of each being only about 16 feet cube. This timber derives its chief value from the figured appearance it presents when cut, or converted in the direction of its medullary rays into boards or veneers for cabinet purposes.

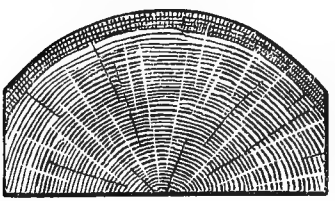

FIG. 22.

Riga wainscot timber passes through the process of bracking prior to its being shipped, and dealers have the option of making their selection from either the Riga, English, or Dutch crown qualities—or the brack quality—at prices varying with the market rates. These stood recently at about 100, 90, 80, and 60 shillings respectively for the log of 18 feet cube, a peculiarity in the mode of selling, which is exclusively confined to this description of timber.

CHAPTER XVII.

THE OAK (*Quercus*)—(*continued*).

THE foregoing are the principal European Oaks at present employed in this country; others have occasionally been brought in, and there are many new and extensive sources of supply open to us whenever it may be necessary to draw upon them.

A few years since I surveyed several fine forests of Oak in Belgium, consisting chiefly of trees of straight growth and superior dimensions. The wood of these was less hard and horny, and of slightly inferior quality to the English and French Oaks, but otherwise it was quite suitable for architectural and other works. There is, therefore, reason to believe that much good timber might be drawn thence. Very good samples of Oak timber have been imported from Piedmont. The quality closely resembles that of the Oak found in the west of France.

Parcels of Dutch or Rhenish Oak were a short time since brought into the London market; they were all apparently cut from a dwarfish tree which yielded only short thick pieces of timber, and these were dressed to produce a greater curve than was natural to them, with the view to make them appear fit for use in ship-building. The wood was brown in colour, plain in grain, of a

moderate degree of hardness and strength, but with nothing in its appearance to recommend it to favourable notice. The private ship-builders therefore declined to use it, and as upon trial it was found unsuitable for the royal dockyards, none has of late been imported.

TABLE XXXVI.—DUTCH OR RHENISH OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	3·50	·25	5·25	658	1035	635	164·50
2	4·00	·25	6·65	650	1100	650	162·50
3	3·50	·30	6·75	625	1020	612	156·25
4	3·50	·35	7·15	630	940	670	157·50
5	3·25	·25	8·00	710	1082	656	177·50
6	3·50	·25	6·50	680	1080	630	170·00
Total .	21·25	1·65	40·30	3953	6257	3853	988·25
Average	3·54	·275	6·716	658·8	1043	642	164·71
E = 276550. S = 1729.							

REMARKS.—Each piece broke with a moderate length of fracture.

Oak timber has also been imported from Spain in considerable quantities, for ship-building and other purposes. The logs were generally small, or, at the best, of only medium dimensions, curved or crooked at the butt end, and tapering rather quickly towards the top. The wood of the Spanish Oak is of a dark brown colour, plain and even in its grain, porous, softer than most other Oaks, and liable to excessive shrinkage in seasoning.

The star-shake defect is common to it, and, taken altogether, it is of very inferior quality. The Spanish Oak did not meet with approval in either the royal or private ship-building yards, and consequently the shipments of it to this country have declined for some time past. It is remarkable that this Oak is of very slow growth (*vide* Table II., p. 17); and perhaps this in some measure accounts for its inferior quality, our theory being that the trees of the same species which mature their wood most rapidly are generally the best of their kind.

TABLE XXXVII.—SPANISH OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	4·25	·25	6·00	626	1032	606	156·50
2	3·50	·20	6·15	616	1076	572	154·00
3	3·65	·25	5·65	544	1030	528	136·00
4	4·75	·35	7·75	509	1066	477	127·25
5	3·85	·25	8·00	578	1020	566	144·50
6	4·15	·20	6·15	497	1028	483	124·25
Total .	24·15	1·50	39·70	3370	6252	3232	842·50
Average	4·025	·25	6·616	561·66	1042	538·66	140·416
E = 239190. S = 1474.							

REMARKS.—Each piece broke short; in no instance was there more than 3 to 4 inches of fracture.

There are, besides the Oaks already mentioned, several others which have not yet been brought sufficiently into use for their capabilities to be fairly tested; and among these are the Oaks of Turkey. In

the year 1859, when the supply of British Oak was thought to be insufficient, and the Italian forests were showing signs of clearance and gradual exhaustion, the Admiralty, deeming it prudent to seek for other sources of supply for the service of their dockyards, directed surveys of the Oak forests in the district of Broussa, in Asia Minor. Having been intrusted with this duty, I found a vast number of very fine Oak trees, both of straight and compass form. Without doubt much good timber exists there; it is not, however, nearly equal in quality to the British Oak, although it would be likely to prove a good substitute for it if need required.

Two kinds of Oak were met with in the forests to the south-east of Broussa, that upon the upper ranges of the mountains being similar in foliage and fruit to the English *Quercus Robur*; the other species, which is found chiefly upon the slopes and in the valleys, is the *Quercus Cerris*, or Mossy-cupped Oak.

It is from these forests that most of the supplies are drawn for the service of the imperial dockyards at Constantinople and Gimlek; the Turks very carefully selecting the cleanest-grained trees for employment, and apparently neglecting the hard, gnarly-looking trees that would be difficult to work. They seem generally to be quite content with a mild and free specimen, which would require little labour to dress it to the necessary form; and therefore no correct opinion of the quality of the timber in the forests of the Broussa district can be formed from that seen in use in the naval establishment on the Golden Horn.

In the following year (1860) I made an inspection of several of the forests in Herzegovina, Bosnia, and Croatia, in European Turkey, and also some of the Oak forests in Styria and Hungary, meeting with almost inexhaustible

quantities of Oak spread over the slopes of the Kogaratz mountains, and in the district between the rivers Verbas and Okrina.

The Oaks seen over this wide range were chiefly of the *Quercus sessiliflora* species, but mixed occasionally with the *Quercus Cerris;* they were all of straight growth, with long clean stems, and generally of good quality, but varying considerably in this respect according as the situation and soil were favourable or otherwise to the development of their character. There is, however, good reason to believe that by selecting from the best description of Oak trees in the districts I have named, very large and valuable supplies might be obtained; but at the time spoken of no attempt had been made to fell them for the many purposes for which their quality and size would render them available. The principal, and almost the only use hitherto made of any of these noble trees, is to cut them down and cleave them into staves for casks.

Bordering close upon the east side of Bosnia, but in the State of Servia, there are immense forests of Oak. These, however, I was unable to penetrate, owing to the lateness of the season and unfavourable state of the weather.

Hungary also possesses large forests of Oak, stretching from Resnek and Kaniza to the Danube. These again might undoubtedly be worked with great advantage, the trees being mostly of good quality, and remarkable for their straight growth and noble dimensions. In Styria could be found only a scanty stock of Oak, the forests having been exhausted some few years prior to the date of my visit. New supplies are, however, springing up, and ere long a very valuable property in this description of timber will be found there.

Passing now from Europe to America, it will be well to describe three or four of the most valuable kinds of Oak which have been dealt with commercially and employed in this country. There are many others, spread over that vast continent; but, as they are little known here and not likely to be required, they will be only briefly noticed.

CHAPTER XVIII.

THE AMERICAN WHITE OAK TREE (*Quercus alba*).

THIS tree derives its name from the pale ash colour of its bark, and is said to flourish in every variety of soil, but best upon open ground at a moderate elevation, some of the finest specimens being found in Maryland. It is abundantly spread over a very large tract of country, and, according to Michaux, it extends from the 28° to the 46° of North latitude, and towards the west to the State of Illinois.

In the open grounds the trunk of this tree is of only moderate length, but in the forests it frequently attains the height of from 40 to 60 feet, clear of branches, with a circumference of from 7 to 8 feet, and very noble logs of timber are produced from it. Those which I have seen imported into this country have invariably been straight, and hewn to correspond in appearance with our English Oak "sided" timber; some of the logs were very large, but generally they varied from 25 to 40 feet in length, and from 12 to 28 inches in the siding or thickness.

Thick-stuff of from 10 to 4½ inches, and plank of 4 to 2 inches, of very superior lengths, fair growth, and free from knots, have usually formed part of the shipments. There is, however, scarcely any compass timber to be found beyond the little that can be obtained from

the branches, or from the spurs of the roots, which are often very large.

The wood is of a pale reddish-brown colour, straight-grained, moderately hard and compact, tough, strong, and of fair durability. Being remarkable for its elasticity, planks cut from it may, when steamed, be bent into almost any form or curve, no matter how difficult, without danger of breaking or splintering them. This characteristic renders it especially valuable for ship-building purposes.

This wood opens very sound; and as it shrinks but little, and almost without splitting, during the process of seasoning, there is nothing to prevent its extensive use in railway carriage-building, civil architecture, and generally in the domestic arts. I have known it to stand the test of many years' exposure in the open without being more than very slightly deteriorated thereby. It will therefore be safe to say that it is by far the best foreign Oak timber, of straight growth and large dimensions, for constructive purposes that has ever been imported.

The American White Oak timber, introduced in 1861 by Mr. Donald McKay, of Boston, U.S.A., was used in the royal dockyards as a substitute for British Oak, chiefly for beams, keelsons, and other works requiring large scantlings. At the moment of its introduction, however, the great change took place by which iron was substituted for wood in ship-building; consequently the demand for it fell, and, owing to the large stock of other woods at the time upon hand, it was difficult to employ it profitably. Ultimately it passed away in the repairs of ships and some minor services. Very little of this wood has ever been placed upon the London market for employment in the private trade.

In the experiments that were made, it was found White Oak compared very favourably with all the foreign Oaks, but proved to be slightly inferior in strength to the English Oak.

TABLE XXXVIII.—AMERICAN (OR PASTURE) WHITE OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·65	·15	9·00	836	960	871	209·00
2	1·50	·00	8·50	826	988	836	206·50
3	1·75	·25	9·25	839	950	883	209·75
4	1·75	·10	10·15	882	1010	873	220·50
5	2·35	·35	9·35	744	935	795	186·00
6	2·50	·35	6·75	696	1054	660	174·00
Total .	11·50	1·20	53·00	4823	5897	4918	1205·75
Average	1·916	·208	8·833	803·83	982·8	819·66	200·96

REMARKS.—Nos. 1, 2, 5, and 6 broke with a splintery fracture, 10 to 12 inches in length; 3 and 4, although splintered like the others, were not completely broken asunder.

TABLE XXXIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	988	28,004	7,001
8		960	31,076	7,769
9		935	26,600	6,650
10		1010	31,228	7,807
11		950	23,512	5,878
Total . .	...	4843	140,420	35,105
Average .	...	969	28,084	7,021

TABLE XL.

Vertical or Crushing Experiments.

Nos.	Dimensions.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Total Tons.	Average Tons.	Ditto on 1 square inch.
12—17	1 × 1 × 1	3·125	3·00	3·125	3·000	3·250	3·500	19·000	3·166	3·166
18—23	2 × 2 × 2	12·000	12·75	12·500	12·125	12·750	12·500	74·625	12·437	3·109
24—27	2 × 2 × 1·2·3·4	9·750	9·06	9·750	10·250	...	...	...	...	...
28	3 × 3 × 3	22·500	...	...	...	...	...	...	22·50	2·50
29	4 × 4 × 4	33·000	...	...	...	...	...	...	33·00	2·06
30	9⅛ × 9⅛ × 15	247·000	...	...	...	...	...	...	247·00	2·97
31	9⅛ × 9⅛ × 24	247·000	...	...	...	...	...	...	247·00	2·97
32	12 × 12¼ × 30	338·000	...	...	...	...	...	...	338·00	2·30

E = 528650. S = 2110.

CHAPTER XIX.

THE AMERICAN LIVE OAK TREE (*Quercus virens.*)

THIS tree is of very moderate dimensions when compared with the White Oak, its usual height being only about 35 to 45 feet, with a diameter of 12 to 18 inches. It is an evergreen, and is found principally in the Southern States of North America, and near to the sea-coast, which it seems to prefer to the more inland and sheltered situations.

The wood is dark brown in colour, hard, tough, strong, heavy, and very difficult to work, on account of the grain being waved or twisted. Its pores are very minute and the medullary rays unusually bright and distinct.

The largest logs of live Oak that I have seen imported did not exceed about 18 feet in length by 12 inches square, and generally they were of much smaller dimensions. They are usually of a crooked or compass shape, and are, therefore, very suitable for the framing of ships of from 300 to 800 tons burthen, in which only small scantlings are required. It is used extensively for this purpose in the Southern States; it makes good mallets for carpenters, and would be useful for cogs in machinery, and many other services where great weight is not an objection.

Judging from the appearance of this timber, it is stronger than any other known Oak, but, as it was impossible to obtain a single straight specimen of the prescribed dimensions, viz., 2 × 2 × 84 inches, the usual tests could not be applied, and there are consequently no tables to show what it would actually bear.

THE BALTIMORE OAK TREE (*Quercus*),

so called from the shipments being made chiefly from Baltimore, is a perfectly straight timber, and is brought to us in lengths varying from 25 to 40 feet, the squares, or sidings, being from 11 to 20 inches.

The wood is of a reddish-brown colour, somewhat darker than the White Oak, and less hard and horny in texture; it is moderately strong, and the quality fair. It might be used with advantage for many minor fitments in ships, and for general purposes in carpentry, as it is easy to work, and stands well after seasoning. It is not, however, recommended for use where great strength is required, as, when thoroughly dry, it is scarcely so strong as the best Fir or Pine.

The Baltimore Oak tree is of very slow growth (*vide* Table II., p. 17), and the timber would soon decay unless well protected by paint or varnish after seasoning.

TABLE XLI.—AMERICAN (OR BALTIMORE) OAK.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·00	5·00	651	820	794	162·75
2	1·25	·15	7·50	837	695	1200	209·25
3	1·35	·25	8·25	769	738	1042	192·25
4	1·50	·15	7·15	729	736	990	182·25
5	1·85	·25	7·65	627	734	854	156·75
6	1·65	·35	7·25	723	758	967	180·75
Total .	8·85	1·15	42·80	4336	4481	5847	1084·00
Average	1·475	·191	7·133	722·66	746·83	974·5	180·66

REMARKS.—Nos. 1, 3, and 6 broke quite short; 2, 4, and 5 with a scarph-like fracture, about 8 inches in length.

TABLE XLII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	758	19,600	4,900
8		736	19,052	4,763
9		734	11,748	2,937
10		738	10,920	2,730
Total .	...	2966	61,320	15,330
Average	...	741·5	15,330	3,832

TABLE XLIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 11.	No. 12.	No. 13.	No. 14.	No. 15.	No. 16.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·75	10·75	10·5	10·5	10·5	10·125	63·125	10·521	2·630

E = 703230. S = 1897.

THE CANADIAN OAK TREE (*Quercus Rubra*).

THIS tree is of perfectly straight growth, and yields the timber of commerce in logs varying from 25 to 50 feet in length by 12 to 24 inches square.

The wood is brown in colour, has a fine straight clean grain, is somewhat porous, shrinks moderately without splitting, is easy to work, and stands well after seasoning. It is remarkable for its very slow growth.

About 4,000 loads of this Canadian Oak timber are usually imported annually into London, and a far greater quantity into the Liverpool market, for the use of cabinet-makers and general dealers, who employ it for

the manufacture of furniture, and in the domestic arts; but, as a building wood, it can never be in favour, and is quite unfit for architectural or engineering works requiring strength or durability.

The Canadian or Quebec Oak is generally quoted in the market at about 20 per cent. higher than the Baltimore Oak, but probably this is chiefly owing to its superior dimensions rather than to any difference in the quality.

America produces, besides the foregoing, the Swamp White Oak, *Quercus bicolor*; the Rough or Post Oak, *Q. stellata*; the Rock Chestnut Oak, *Q. montana*; the Black Oak, *Q. tinctora*; and the Scarlet Oak, *Q. coccinea*; all these are largely used in architectural works, and for agricultural implements, both in the United States and in Canada.

THE WALNUT TREE (*Juglans*)

is found widely spread over Southern Europe, in many parts of Asia, and also in North America.

That which is brought from Italy is a light-brown wood, close and fine in the grain, with occasionally dark veins, and some waviness of figure; it is hard, heavy, solid, and with scarcely any disposition to split in seasoning. Planks 4 to 9 inches thick, square edged, 10 to 16 inches broad, and 5 to 12 feet in length, are imported and sold, sometimes by weight, at other times by the superficial foot of 1 inch thick.

The Black Sea Walnut wood is imported in logs of 6 to 9 feet in length by 10 to 18 inches square, imperfectly hewn, a considerable quantity of wane being usually left upon the angles. The wood is similar in colour and texture, but slightly inferior in quality, to the

Italian Walnut wood; it is dealt with in the market under the same conditions.

Burrs or excrescences, frequently measuring 2 to 3 feet across by 12 to 15 inches in the thicker part, and weighing 5 to 6 cwt. each, are common to the Walnut trees of Italy and the Black Sea; they are often prettily mottled or figured, and make rich and splendid veneers for the cabinet-maker; those of the best quality are consequently much prized, and have been known to realise £50 to £60 per ton weight.

The wood of the American Black Walnut tree is whitish-brown in colour, moderately hard, straight and plain in the grain, splits freely, and is easy to work. It will not bear comparison with the quality of either the Italian or Black Sea Walnut wood. The trees are large enough to yield building scantlings, the logs as imported being usually about 15 to 30 inches square, imperfectly hewn, by 10 to 20 feet in length. Owing to the liability of the logs to split from the centre, the ends have generally a red colouring matter put over them before shipment, to protect them against atmospheric influences.

This wood is sold at per foot cube. There is only about ¾ inch of sapwood on the Walnut trees above mentioned.

The uses of Walnut wood are chiefly for furniture and pianoforte making. It is also much prized for gun-stocks; but there are many other ways of employing it profitably in place of mahogany and other furniture woods.

CHAPTER XX.

THE TEAK TREE (*Tectona grandis*).

THIS tree is found principally in India; and from the southern limits of its range in Java it is distributed over about 2,000 miles, until it touches close upon the 23° of North latitude. Its range in longitude is also very considerable, since it is found to stretch across Hindustan, and through Burmah to near the frontier of China. It was formerly very plentiful in the Malabar district, but is now only sparingly met with there. At Bombay, where a few years since it was supplied in sufficient quantities from the adjacent province to meet all the demands for ship-building and other purposes, builders have now, owing to its almost complete exhaustion, to draw upon other sources to meet the local requirements.

The most extensive, and probably the best, forests of Teak at present existing are in Burmah, where they lie spread along the banks of the Salween, Thongyeen, Irrawaddy, and other rivers. They also stretch very far inland to the countries occupied by the Shans, the Karens, and the Chinese. Other forests stretch considerably to the north, and there, upon some of the undulating and mountainous districts, it becomes dwarfed to a rather insignificant tree. Teak is also

believed to be plentiful in Siam,* and is found on several of the islands in the Indian seas.

The Teak is a deciduous tree, and prefers shelter to bring it to the greatest perfection. It is of straight growth, and is remarkable for its large drooping leaves, which are from 10 to 20 inches in length, and from 8 to 15 inches in breadth. It frequently attains the height of 80 or 100 feet, with a circumference of from 6 to 10 feet, and yields timber in the log 23 to 50 feet in length and 10 to 30 inches square, these being the sizes commonly shipped to this country.

The wood varies from yellow or straw to a brownish colour; is moderately hard and strong, clean, even, and straight in the grain, and is easily worked; it shrinks very little in seasoning, and has no shakes upon the outer surfaces of the log. It will split, however, unless care is observed in applying the fastenings when brought into use. The quality of the timber depends very much upon the locality in which it is grown, and is exceedingly variable. Teak wood contains a resinous oil which clogs its pores and resists the action of water, and it often oozes into and congeals in the shakes which radiate

* Since the foregoing was written, a sample of about 200 loads of Teak timber, the produce of Siam, has been imported into London from Bangkok (1873). In dimensions it compared favourably with the Burmah Teak, was quite straight, and of a pale yellowish colour, plain in the grain, moderately hard, and apparently of about the same specific gravity. As a parcel, however, it was faulty at the pith or centre, in having most injurious heart and star-shakes, only about 20 per cent. of the logs being fit for conversion into plank or board; the remainder, owing to the defects referred to, could only be profitably employed in bulk, or reduced to scantlings, which would involve a heavy loss.

The sound and solid wood in the logs, however, was very good; and I am of opinion that if the timber is only carefully sorted over at Bangkok, good shipments might be made for the London market.

from the pith, forming there a hard concrete substance, which no edge-tool can touch without losing its keenness. The oil also acts as a preventive against rust when iron is in contact with it, and for this reason it is preferred to all other known woods for the backing to the armour-plates of iron-clad ships of war. It possesses, indeed, so many valuable properties, that it has long been held in great esteem as a material for construction, while its economical uses are so great, that there is no carpenter, or other worker in wood, who does not, after having once tried it, fully appreciate its value.

In favourable situations the Teak tree grows to a sufficient height to furnish the lower masts for ships of 2,000 tons burthen, and it is commonly employed for this purpose in the East Indies. It is naturally a tall tree, and I am of opinion that greater lengths of timber might be produced from it than we generally receive, if only a little more care were taken to prevent waste in the forests. Ordinarily the practice is to cut off the bole or stem below the branches; whereas, in many cases, it would be easy to include in it the knots of some of the lower ones, and thus gain a foot or two more of length in the log, which the ship-builders and many others would consider to greatly enhance its value.

In the late contracts for this description of timber for the royal dockyards, it was stipulated that the minimum length of the log should be 24, and the average 28 feet, but as of late it has been found difficult to obtain this average from the Moulmein district (whence nearly all our supplies have been drawn for many years past) the minimum and average length has been reduced respectively to 23 and 27 feet.

The Burmese assign two reasons for not aiming to produce a better average length of log; one is, that

the greater the length, the greater is the difficulty of moving and getting them out of the forests to the streams, and the increased danger when there of entanglement in the short bends of the water-courses. Another is, that the long logs were, until quite lately, liable to some trifling duty; while upon the short pieces coming from the forests, no charge whatever was levied on their arrival at Moulmein.

It is the practice in Burmah to girdle the Teak trees three years before they intend to fell them; a complete ring of the bark and sapwood being cut through and removed in order to kill the tree. This object is very soon obtained, as in a few days, or at most a few weeks, the tree is dead; the natural juices contained in it are, therefore, gradually run off by the root while the tree stands. This and the great heat of the climate combined, seasons the wood, and renders the log—which, in its green state would have a specific gravity of at least 1·000, and be difficult to move if felled—so much lighter that it floats easily over the shallows of the streams or rivers to the port of shipment. And as usually about a year elapses between the felling and the delivery of the timber in England, it is commonly received in a fit state for immediate use.

The practice of girdling is, I think, objectionable, inasmuch as the timber dries too rapidly, is liable to become brittle and inelastic, and leads frequently to the loss of many fine trees by breakage in falling; further, it must be regarded as so much time taken from the limit of its duration, which is of great importance.

Girdling has been discontinued in the Annamallay forests of Malabar, under the impression that it causes, or at least extends, the heart-shake; it is, however, practised in Cochin, Travancore, and a few other places;

but, as the evidence of its utility goes no farther than to show the advantage gained in being able to float the timber immediately it is felled, it seems probable that before long it will be given up entirely. Experiments have been made in Burmah* in felling green Teak, but, as out of 100 trees so felled, twenty-seven in number had extensive heart-shake, and ten others were less seriously affected, it was thought desirable to carry the experiments farther before determining the matter in question.

Although imported and known under the general name of Teak, there are many varieties, if not distinct species of it, the Burmese naming those found in their country after the districts in which they grow; thus, in the Moulmein district there are the Thoungyeen, the Salween, the Karanee, the Attaran, and the Laingbooe Teak; and in the Rangoon district, the Irrawaddy Teak, all differing slightly in colour, grain, texture, and specific gravity.

The Thoungyeen and the Salween Teak timber are of a yellowish-brown colour, smooth and uniform in their texture, with a fine long grain. The Karanee Teak has alternate shades of dull brown and yellow colour, the grain being close and long, with occasionally a rowiness, or figure, in it, and is also very free from defects. The Attaran Teak is rather stunted in growth compared with the varieties just mentioned, but is of fully the same circumference. The wood is brownish in colour, dense, hard, and resembles very much the Malabar Teak. It is heavier than either the Thoungyeen or Karanee, and is also coarser and more knotty, owing to the branches occurring lower down the stem. Some of these, from accident or otherwise, get broken off, and defects, arising

* Forest Reports.

from the moisture lodging in the ruptured parts, are not unfrequent in it.

The Laingbooe Teak has a most peculiar growth, and deviates strangely from the ordinary cylindrical form, in having its stem twisted and deeply grooved, or fluted. It consequently takes a tree of rather large size to yield a small straight square log, and when obtained it is but an indifferent one, owing to the fibre of the grain having been cut and weakened by the hewing of an irregular form or shape into a regular one. In colour this wood is rather darker than any of the others, and it is also considerably harder and heavier.

The Irrawaddy or Rangoon Teak timber is of a pale yellow colour, very closely resembling the Thoungyeen Teak of the Moulmein district in its uniformity of texture, and in having a long straight grain. It is a clean free kind of wood, with the centre commonly softer and more spongy than the outer annual layers. In consequence of this it cuts transversely, with a coarseness and fluffiness of surface near the pith which is remarkable; this, I consider, may be taken as indicative of poorness or inferiority in the quality.*

It is also characteristic of the Rangoon or Irrawaddy Teak to be shaky at the centre, there being, besides the heart-shake, which is common more or less to Teak timber, a close, fine, star-shake, radiating from the pith, which is seriously detrimental to its value. Many of the logs cannot, therefore, on this account be converted into planks and boards without incurring a very considerable

* The dealers in Rangoon Teak wood say that the soft spongy appearance is of no consequence, as it is merely caused by the workmen having used a coarse cross-cut saw for butting and topping the logs, in place of an ordinary fine-toothed one, that would be better fitted for it.

loss. If, however, it is used in bulk, or in stout scantlings, as for backing to armour-plates on ships, or in batteries, or any similar works, it answers equally well with the Moulmein Teak, the risk being in attempting to reduce it into thin planks. The Rangoon Teak is straight, and yields a better average length of log than is to be found in those of the Moulmein district; the dimensions of the squares are, however, nearly alike.

In Malabar, the largest forests of Teak trees are to be found upon the Annamallay hills, at an elevation of about 1,500 to 3,000 feet above the level of the sea. They consist, however, for the most part, of saplings and trees past their prime, the most useful having been felled and removed long since, a few trees of excessively large growth only being left available for the purposes of commerce.

The Teak grown on the Annamallay hills is subject to extensive heart and other shakes about the centre of the tree, and this involves great waste of timber, as only the flitches taken from the outside part are available for use. Attempts have been made to produce "squares" and "planks" by the use of the saw upon pits, and by machinery, but it was found not to answer; the logs were, therefore, cleaved by wedges along the run of the heart-shake into two segments, and from these "squares" "planks" and various scantlings were produced by the axe, quite clear of shakes.

The Malabar Teak is very good in quality, and is generally darker in colour, denser, and a trifle stronger than Burmah Teak, when tested, one piece against another. But, as the trees are so much less useful on account of the defects before mentioned, it is probable the Burmah Teak will always have the preference for

manufacturing purposes. Malabar Teak is a few pounds heavier per cubic foot than Burmah.*

I tested, when in Burmah, all the varieties of Teak that were then drawn from the Tenasserim forests, and found a very considerable difference in their transverse strength; this, however, may probably be attributed to the variations of soil, and to the length of fibre in the grain.

Thus the transverse strength of the Thoungyeen was proved to be 284 lbs., the Karanee 271 lbs., the Attaran 201 lbs., and the Laingbooe only 175 lbs. per square inch, the mean strength being 233 lbs. per square inch. The several specimens tried were each of them 2 × 2 × 84 inches, supported on props 6 feet apart, with the weight applied, as usual, in the middle; the result being that the Thoungyeen and the Attaran both broke with a long splintery fracture, while the others snapped off very short.

In some experiments more recently conducted in this country on twelve pieces of Moulmein Teak of the same dimensions as above, the results gave, as the mean breaking weight, 220 lbs. to the square inch, which is less than the average of the four varieties just mentioned, and 32 lbs. below the average of the three first named; the Laingbooe being struck out as not likely ever to be imported in sufficient quantities to affect the results when applying Teak to building purposes. The dif-

* An effort has recently been made to open up afresh the resources of the Annamallays; but owing to the faulty character of the trees, and from having to convey the logs a distance of about forty miles by land-carriage to a port of shipment, it is thought to be extremely doubtful whether it can ever compete in the European market with the Teak timber of Burmah.

ference is against the specimens tried in England, but this may be attributed mainly to the more seasoned state of the pieces, and, perhaps, in part, to better appliances for testing.

The mean deflections of the twelve pieces referred to, were, when weighted to 390 lbs., 1·791 inch, and with the breaking weight of 878 lbs., 5·916 inches. From these results it appears, by the application of the formulæ used by Professor Barlow, that the strength is represented by 2303, and the elasticity by 530970. The same pieces being tested for tensile strength, took a strain nearly equal to 6 tons to overcome the direct cohesion, or about 3,301 lbs. to the square inch.

A number of cubes of this timber were subjected to a crushing force in the direction of the fibres, and these generally gave way under a pressure of about 2½ tons per superficial inch of base. Altogether, some fifty-three experiments of this kind were made upon Teak, four being on pieces 2 × 2 of various lengths, others were 3 × 3, varying by 1 inch from 8 to 18 inches in length, the piece of 16 inches proving to be the strongest, and taking 28·75 tons to crush it; then there were pieces 4 × 4, and severally varying by 1 inch from 15 to 24 inches in length, the piece of 20 inches proving to be the strongest, and taking 42 tons to crush it. Again, there were pieces 6 × 6, and severally varying by 3 inches from 12 to 30 inches in length, the piece 18 inches in length taking 174 tons to crush it; and finally, there were other pieces 9 × 9¼, varying by 3 to 6 inches from 12 to 30 inches in length, the strongest of which, 21 inches in length, took 368·6 tons to cripple it; the details of these will, however, appear in Tables XLVIII. and XLIX.

The following experiments were made in order to

test the deflections of Teak under given weights at various distances, viz. :—

TABLE XLIV.

Nos. 1 to 6.

Specimen, 2 × 2 × 84 inches, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300lbs., the deflections were	·065	·300	·750	1·250ins.
,, ,, 400lbs., ,, ,,	·300	·600	1·150	2·050 ,,

Specimen, 2 deep × 1½ broad × 84 inches, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300lbs., the deflections were	·300	·400	1·100	2·100ins.
,, ,, 400lbs., ,, ,,	·400	·800	1·500	2·800 ,,

This piece, tried the other way, viz.:—

1½″ deep × 2″ broad, supported on props,	3 ft.,	4 ft.,	5 ft.,	6 ft. apart.
Weighted with 300lbs., the deflections were	·200	·800	1·600	3·200ins.
,, ,, 400lbs., ,, ,,	·500	1·200	2·600	Broke.

The specific gravity of these pieces was respectively ·586 and ·631 ; a proof that they were thoroughly seasoned. Upon the laws which govern these deflections, I offer no opinion, and the experiments are merely introduced here to show how near the results go to confirm Professor Barlow's theory that the strength varies as the cubes of the length.

There is one other species of trial which it may be well to mention, namely, that to ascertain the elongation

of the fibres of Moulmein Teak in a length of 3 feet under certain strains. Three pieces, each 2 × 2 × 48 inches, were thus tested, at one of the royal dockyards, and it was found that the mean elongation was nearly a quarter of an inch. (See Table L.)

The Teak tree is subject to a wasting away of the early annual layers long before it reaches maturity; and the number of young trees found thus affected in the rafts brought from the forests to the shipping port is very remarkable. The surveyor judging only from the deliveries of Teak in this country would hardly be aware of this, as hollow trees would not be selected for the European market.

Teak timber is also subject to heart-shake, as before observed, and in many logs, especially if they are procured from old trees, it is found to extend to one-half, and sometimes to two-thirds the diameter of the tree, and stretching along the entire length of it. If this shake is in one plane throughout, the conversion of the log involves no greater difficulty or loss than that occasioned by dropping out a piece large enough to include it. When, however, as in other instances, the cleft or shake at the top is at right angles, or nearly so, to that at the butt end, it is rather more serious, as the log must either be used in its greatest bulk, or worked up for small scantlings, such as could be obtained if it were cut into two or more lengths.

If the shake extends only a few feet up from the butt end, the most profitable way of converting the log would be by cutting it into plank or board, taking care to work from the outside instead of the centre, and thus waste only a tapering or wedge-like piece, sufficient to include the defect.

Many Teak logs are worm-eaten; holes from a

quarter to half an inch in diameter are found upon the surface, which often penetrate deeply and in all directions. Such logs have generally a dull appearance, and are invariably brittle and of inferior quality. This defect is, I consider, indicative of an unhealthy if not dead state of the tree, before it was cut down.

The ravages of the worm are detrimental to the strength and value of the timber, and logs so affected are not fit to be reduced to plank for use on bottoms of ships.

Teak, notwithstanding its defects, is extensively used for ship-building in this country, in place of English and other Oaks, African and Sabicu timber, &c., &c., and the objection that was formerly made against its use in ships of war, as being unsuitable, on account of its liability to splinter if struck by a shot, is no longer allowed to stand in the way of its employment.

Teak timber is also used, to a moderate extent, for ship-building in the arsenals of foreign countries.

The quantities of Teak timber received here annually from Moulmein have hitherto been very large, and so greatly in excess of that which it was calculated a few years ago could be drawn from the Tenasserim forests, that fears have been entertained the supply from that source must soon fail, and we notice a falling off in the shipments. This has, however, been supplemented by the shipment of considerable quantities of Teak from Rangoon, and it seems probable that that port will soon become the chief timber station for the export of this important article of commerce.*

I do not, with this new source of supply open to us,

* Between 1865 and 1870, inclusive, Moulmein sent to Europe 147,421 loads, and Rangoon 28,821 loads of Teak timber.

apprehend that any serious difficulty is likely to arise for some time to come; but, happen when it may, there are yet the forests of Siam, which are said to be very extensive, and also those of Java, almost untouched; and from these, I imagine, the future supplies for the European market could be drawn.

Teak timber is sorted into A, B, and C classes in the London market, according to dimensions, not quality, A class or pile being 15 inches and upwards on the larger side, and 23 feet and upwards in length; B, ditto ditto, 12 and under 15 inches on the larger side, and 23 feet and upwards in length; C, ditto ditto, under 12 inches on the larger side, and 23 feet and upwards in length; D are damaged logs. B and C classes are usually sold at about 10 to 20 shillings per load under the price for A pile timber.

The value of Teak in the London market has fluctuated very much. In 1859 and 1860, the market being overstocked, it stood as low as £10 to £11 per load of 50 cubic feet; but, in 1861, when there was a sudden and unexpected demand for timber generally, it rose to £16 per load; it soon, however, declined again, and is now (1875), with a stock of about 8,000 loads of Moulmein and Rangoon upon hand in the London market, to be had at about £12 to £14 per load.

TABLE XLV.—BURMAH (OR MOULMEIN) TEAK.—NO. 1.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
7	2·05	·25	5·50	840	712	1179	210·00
8	1·35	·10	4·50	971	787	1233	242·75
9	1·75	·15	4·75	867	840	1032	216·75
10	1·65	·00	5·00	915	724	1277	228·75
11	1·75	·00	7·50	923	720	1282	230·75
12	1·35	·00	5·00	960	874	1098	240·00
Total .	9·90	·50	32·25	5476	4657	7101	1369·00
Average	1·65	·083	5·375	912·66	776·16	1183·5	228·16
E = 576220. S = 2394.							

REMARKS.—Each piece broke short to the depth of about one-third, then with scarph-like fracture, 8 to 12 inches in length.

TABLE XLVI.—BURMAH (OR MOULMEIN) TEAK.—NO. 2.

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
13	1·25	·0	5·25	950	910	1044	237·5
14	2·10	·0	7·00	850	821	1035	212·5
15	1·75	·0	7·00	920	805	1018	230·0
16	1·90	·0	6·75	816	790	1033	204·0
17	1·50	·0	6·50	920	800	1150	230·0
18	3·15	·5	6·25	602	726	829	150·5
Total .	11·65	·5	38·75	5058	4852	6109	1264·5
Average	1·942	·083	6·485	843	808·66	1018·16	210·75
E = 485720. S = 2213.							

REMARKS.—Each piece broke short to the depth of about one-fifth, then with scarph-like and fibrous fracture, 10 to 14 inches in length.

TABLE XLVII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
19	2 × 2 × 30	787	14,564	3,641
20		800	16,240	4,060
21		724	10,916	2,729
22		805	14,000	3,500
23		726	10,368	2,592
24		821	13,152	3,288
Total .	...	4663	79,240	19,810
Average .	...	777	13,207	3,301

TABLE XLVIII.

Vertical Experiments on Cubes of

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
25 to 28	2·375	12·500	23·75	37·5
29, 30	2·500	12·500	—	—
31, 32	2·625	10·750	—	—
33, 34	2·500	10·500	—	—
35, 36	2·125	10·750	—	—
37, 38	2·375	11·125	—	—
Total . .	14·500	68·125	—	—
Average .	2·4166	11·354	23·75	37·5
Do. per in.	2·4166	2·838	2·64	2·343

TABLE XLIX.

Vertical Experiments.

Number of the specimen.	Dimensions of the pieces.		Specific gravity.	Crushed with	Ditto on the square inch.
	Inches.	Length. Inches.		Tons.	Tons.
39	2 × 2	1	760	13·750	3·437
40		2	730	11·354	2·838
41		3	770	12·875	3·219
42		4	780	13·750	3·437
43	3 × 3	8	744	18·000	2·000
44		9	704	18·500	2·055
45		10	653	18·000	2·000
46		11	663	18·250	2·028
47		12	640	19·000	2·111
48		13	635	20·000	2·222
49		14	672	23·500	2·388
50		15	678	23·750	2·639
51		16	672	24·250	2·694
52		17	678	24·000	2·666
53		18	661	22·500	2·500
54	4 × 4	15	662	33·5	2·094
55		16	682	34·0	2·125
56		17	724	38·25	2·387
57		18	744	40·25	2·515
58		19	699	37·00	2·312
59		20	756	42·00	2·625
60		21	761	40·25	2·515
61		22	771	37·00	2·312
62		23	690	37·50	2·343
63		24	644	30·00	1·875
64	6 × 6	12	811	153·0	4·250
65		15	831	163·8	4·550
66		18	831	174·0	4·833
67		21	786	169·0	4·694
68		24	836	122·2	3·399
69		27	693	168·4	4·666
70		30	781	153·0	4·250
71	9 × 9	12	889	307·0	3·776
72	9′ × 9′	15	845	337·8	3·974
73	9 × 9	18	846	286·0	3·530
74	9′ × 9′	18	864	307·0	3·612
75	9′ × 9′	21	828	368·6	4·572
76	9 × 9	24	757	276·2	3·410
77	9 × 9	30	835	307·0	3·790

The mean of Tables XLV. and XLVI. = E = 530970. S = 2303.

TABLE L.

Experiments on Specimens of Teak, to ascertain the elongation of the fibres in a length of 3 feet, under various strains, the dimensions of each piece being 2 × 2 × 48 inches.

Number of the specimen.	2 Tons.	3 Tons.	4 Tons.	5 Tons.	6 Tons.	7 Tons.	8 Tons.	9 Tons.	10 Tons.	Elongation preceding rupture.	Breaking strain.
										Inch.	Tons.
78	1/32	1/16	2/32	2/16	5/32	3/16	...	...	...	3/16	7·75
79	1/32	1/16	3/32	3/32	2/16	3/16	3/16	4/16	5/16	5/16	10·25
80	...	1/32	1/16	2/16	3/16	...	...	...	...	3/16	7·00
The mean.	·0313	·0521	·0729	·1145	·1249	·187	·187	·25	·312	·229	8·333

CHAPTER XXI.

BURMAH.

THE *Pyengadu*, or Iron-wood tree, the *Ingazylocarva* of the botanists, is a species of Acacia, of straight growth, found in the Burmese forests, and also in the country occupied by the Karens, towards Western China, where it is often seen rising to 70 or 80 feet clear of branches, and of very large circumference. It yields timber in the log 12 to 24 and even 30 inches square, and of great lengths.

The wood is of a reddish-brown colour, hard, heavy, tough, strong, rigid, and frequently possesses some figure in the grain, which has the appearance of being both waved and twisted; its pores are filled with a remarkably thick glutinous oily substance, which oozes out upon the surface after the wood has been worked, leaving a clamminess which cannot be completely got rid of until the piece is thoroughly seasoned. This oily substance has probably a preservative property about it, and may be conducive to the durability of the timber.

The *Pyengadu* was highly spoken of by the officers at Moulmein, who supplied considerable quantities of it to the Madras Government for the manufacture of gun-carriages, and also for other purposes. Although it was

not extensively known then, it was a favourite wood in the East for works requiring strength and durability, and without doubt the samples I met with all looked remarkably well, and seemed fit to be employed in any work of construction where great strength is required.

It is interesting to note that, subsequent to this, Lieut.-Col. H. W. Blake, the Commissioner at Moulmein, brought this wood to the notice of the Home Government. He says; "It is one of the largest trees in Burmah, and is called *Ingazylocarva*, a species of Acacia, which combines in itself the properties of wood and iron, and is therefore very appropriately called Iron-wood by us and *Pyengadu* by the Burmans. It is heavier than water and more indestructible than iron. There is a piece of this wood which supported a Teak figure of 'Godama' taken from Rangoon in 1826, standing in a lake near. The Teak figure has long since mouldered away into dust, but at the pillar I fired a rifle shot, at 20 yards' distance; the ball was thrown back, making no penetration whatever. The wood seems hardened by time and exposure, and it is also a fact that the teredo will not touch it. The Burmans do not girdle and kill this tree as they do the Teak, but fell and saw it up at once, and refuse to work it in a dry state."

Dr. Hooker says: "It is found, not universally in India, but in widely distant parts. Throughout Tenasserim and the Malay peninsula it is called 'Peengado.' It is abundant in the Bombay Presidency, where it is called 'Jambea' and 'Yerool;' in the Godavery forests it bears the name of 'Boja;' it is common at Singapore, and I have ascertained that it is plentiful in the Philippine Islands. Everywhere the wood bears a high character

for hardness and durability; the white ant will not touch it; it shrinks in seasoning one-eighth inch per foot of surface, and the density is 5 lbs. 10 oz. per foot superficial. It is one of seven or eight species of trees which Dr. Falconer, in his report of the Teak forests of Tenasserim, earnestly requests the Indian Government to preserve."

Five specimen logs of the Pyengadu, each about 20 feet in length, and 20 to 24 inches square, were sent to Woolwich Dockyard in 1863, for trial experimentally in ship-building; but, as they were found to have extensive heart-shake, they were scarcely fit for constructive purposes. If, therefore, the heart-shake defect seen in these logs fairly indicates the character of this wood, its value as building timber would be seriously affected. I am, however, of opinion that this is not the case, and that these were probably some chance pieces which happened to be in the way when specimen logs were required. Three of the logs here referred to were kept for several years at Woolwich without any good opportunity offering for their employment, and after this lapse of time they did not appear to have undergone any change, or to be in the slightest degree deteriorated.

The specific gravity of these logs was about 1176, while that given by Dr. Hooker is 1080; the difference is therefore not very important.

I found in the Commissariat Stores at Moulmein, besides the Teak and Pyengadu, many other valuable woods of building sizes, and the following are especially worthy of notice, namely, the Padouk (*Pterocarpus*) of a deep red colour; the Parewah, and the Penthityah, both of a dark reddish-brown colour; the Kammone; the Annan (*Fagræa fragrans*), and the Kamonpew, each

reddish in colour, but rather paler than the Padouk. There is also the Thingan (*Hopea species*), a wood heavier than Teak, and which lasts under water far better. It grows abundantly on the Tavay coast and islands.*

The above are all very compact woods, close and fine in texture, of good quality, and no doubt durable. They have long been in use in Burmah, and in the Madras Presidency, and are fit and suitable for use in works of construction, but, up to the present time, they are scarcely known in this country.

Of a less useful character, but still of some value, is the Thitkado, the Toon of India, a kind of bastard Cedar, which yields timber 11 to 26 inches square, and 14 to 40 feet in length.

The wood is of a pale red colour, clean and straight in the grain, moderately hard, and not difficult to work. It is not mild enough for pattern-making, but, for general purposes in the domestic arts, it might be used in lieu of the better kinds of Cedar from Cuba and Mexico, whenever these are scarce in the market.

The Thitkado is subject to heart and star-shakes, and in seasoning is very liable to split from the surface if left long in the round or unconverted state, consequently we need not look for any very extensive business to be done in it. There have been some importations of this wood into the London market, and to the Continent.

Small quantities of Thitka or Kathitka, a kind of bastard Mahogany, have also been exported from Burmah, for furniture and other purposes, but I have not yet met with it in London. It is thought to be a species of Tiliaceæ, and is named by Kurz as *Pentace Burmanica*.

* Report of the officiating Inspector-General of Forests.

TABLE LI.—IRON-WOOD, OR PYENGADU (BURMAH).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·00	4·50	1240	1150	1078	310
2	1·00	·05	4·60	1250	1225	1020	312·5
3	1·00	·05	4·90	1490	1150	1291	372·5
4	·85	·00	3·25	1110	1165	953	277·5
5	·90	·00	3·50	1130	1225	922	282·5
6	1·25	·10	4·75	1420	1143	1242	355
Total .	5·75	·20	25·5	7640	7058	6506	1910
Average	·958	·033	4·25	1273·3	1176·33	1084·3	318·33

REMARKS.—Nos. 1, 2, 3, and 6 broke with about 12 inches length of fracture, 4 and 5 with somewhat less. All were fibrous and wiry.

TABLE LII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1143	35,840	8,960
8		1150	41,440	10,360
9		1150	40,320	10,080
10		1225	38,640	9,660
11		1165	38,080	9,520
12		1225	37,420	9,355
Total .	...	7058	231,740	57,935
Average	...	1176	38,623	9,656

TABLE LIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 13.	No. 14.	No. 15.	No. 16.	No. 17.	No. 18.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
20·750	20·625	20·875	20·500	21·250	21·000	125·000	20·833	5·208

E = 1,031940. S = 3342.

CHAPTER XXII.

BORNEO AND THE CHINA SEAS.

THE Chow, or Menkabang Penang tree, is found in the Island of Borneo, where it is said to be very abundant. It attains large dimensions, is of straight growth, and yields timber in the log of from 30 to 70 feet in length, and from 15 to 26 inches square.

The wood is of a yellowish or straw colour, close and fine in texture, straight in the grain, hard, heavy, tough, and exceedingly strong. It is used in Borneo and the countries bordering on the China seas, for the masts of junks and other vessels, for house and ship-building, and for a variety of minor purposes.

The earliest importation of the Chow, or Menkabang Penang timber, into this country was, I believe, in 1860–61, when it came direct to the London market, and thence passed into Woolwich Dockyard, to be experimentally employed for beams, keelsons, and other purposes where strong, straight timber is required in ship-building; and in this way it gave every satisfaction.

One or two cargoes of Borneo timber, including the Chow, subsequently reached this country, and were delivered at the northern ports, where they were gradually absorbed, chiefly in ship-building; but, owing to the more extended use of iron in ships, the wood is not now inquired for, and the importations appear, for a time at least, to have ceased.

TABLE LIV.—CHOW, OR MENKABANG PENANG (BORNEO).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·00	·00	2·75	904	1144	790	226·00
2	1·00	·05	4·10	1231	1100	1119	307·75
3	1·00	·00	1·75	766	1136	674	191·50
4	·75	·05	3·50	1122	1124	998	280·50
5	1·00	·05	2·65	814	1070	761	203·50
6	·75	·00	2·25	1013	1120	904	253·25
Total .	5·50	·15	17·00	5850	6694	5246	1462·50
Average	·916	·025	2·833	975	1115·6	874·3	243·75

REMARKS.—Nos. 1, 2, 4, and 6 broke with fractures about 12 inches in length ; 3 and 5, rather shorter.

TABLE LV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1100	25,760	6,440
8		1136	25,760	6,440
9		1144	31,640	7,910
10		1170	31,360	7,840
11		1120	29,456	7,364
Total .	...	5670	143,976	35,994
Average	...	1134	28,795	7,199

TABLE LVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 12.	No. 13.	No. 14.	No. 15.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
22·750	22·500	22·250	22·446	89·946	22·486	5·621

E = 1,013836. S = 2559.

THE PINGOW TREE

is also found in the island of Borneo, where it is said to be plentiful. It is of straight growth and good dimensions, and yields timber of from 25 to 40 feet in length, and 11 to 18 inches square.

The wood is of a dark brown colour, hard, heavy, tough, rigid, and remarkably strong; it is straight in the grain, close in texture, and not difficult to work. It is used in Borneo for all the purposes to which the Chow is applied, except that, as the tree does not attain the same altitude, it will not furnish masts for any but the smaller junks. The characteristic properties of the Pingow are favourable to its introduction for any purpose where great strength is required; and, of the sample logs brought to this country in 1860–61 and at subsequent dates, the whole were passed either to Woolwich Dockyard or to the out-ports, to be employed in ship-building.

TABLE LVII.—PINGOW (BORNEO).

Transverse Experiments.

Number of the Specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·05	3·50	1235	757	1631	308·75
2	·75	·05	3·65	1223	753	1624	305·75
3	·65	·00	4·25	1355	745	1819	338·75
4	·90	·10	3·75	1237	742	1667	309·25
5	·75	·15	4·35	1302	748	1740	325·50
6	·85	·00	3·40	1228	740	1660	307·00
Total .	4·65	·35	22·90	7580	4485	10141	1895·00
Average	·775	·0583	3·816	1263·3	747·5	1690	315·83

NOTE.—All broke short.

TABLE LVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	745	22,400	5,600
8		742	20,440	5,110
9		757	28,000	7,000
10		748	25,480	6,370
11		740	26,600	6,650
12		753	28,560	7,140
Total .	...	4485	151,480	37,870
Average	...	747·5	25,246	6,311

TABLE LIX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 13.	No. 14.	No. 15.	No. 16.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
17·125	18·625	18·125	18·750	72·625	18·156	4·539

E = 1,259690. S = 3316.

THE KRANJI, OR RED KRANJI TREE,

of which it is probable there are varieties of some other colour, is likewise found in the island of Borneo; it is a tree of straight growth and noble dimensions, and compares favourably with the Chow; it was imported in 1860-61 with the latter wood, and ultimately sent to Woolwich Dockyard to be employed for naval purposes.

The wood is red in colour, hard, heavy, exceedingly tough, and is one of the strongest with which we are acquainted, every one of the specimens, when tried transversely, taking a very heavy strain, and breaking with an unusually long fracture; the grain is close and somewhat resembles Cuba or Spanish Mahogany, but is very

plain. It would take a high polish, and, except for the almost total absence of "figure" to give it beauty, it would be valuable for the manufacture of furniture, or any ornamental purposes. The Kranji is chiefly used in Borneo for ship and house-building, but would be useful in a general way, and seems likely to prove fit for many of our requirements.

TABLE LX.—RED KRANJI (BORNEO).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·05	4·50	1,531	1058	1447	382·75
2	·60	·00	4·75	1,519	1067	1424	379·75
3	·50	·00	3·25	1,382	1051	1315	345·50
4	·75	·00	4·00	1,347	956	1409	336·75
5	·65	·05	5·00	1,657	1046	1584	414·25
6	·50	·05	2·75	1,460	998	1463	365·00
Total .	3·75	·15	24·25	8,896	6176	8642	2224·00
Average	·625	·025	4·04	1,482·6	1029·3	1440·3	370·66

REMARKS.—Nos. 1, 5, and 6 broke with very long fracture; 2, 3, and 4 much shorter, and scarph like.

Only one piece of Kranji was tested for tensile strength, and that proved equal to a strain of 10,920 lbs. on the square inch. None were tried under the vertical or crushing strain.

$$E = 1{,}504910. \quad S = 3892.$$

THE KAPOR OR CAMPHOR TREE

is found also in the island of Borneo, and was imported

in 1860-61 with the Chow, Pingow, and Kranji; it is of straight growth and very large dimensions, yielding timber from 25 to 45 feet in length, and from 12 to 24 inches square. It has no rich scent like that of the camphor wood of India.

The wood is light red in colour, and has some resemblance to Honduras Mahogany; it is plain, close and straight in the grain, moderately hard and tough, and nearly as strong as the Pingow. The defects of this wood are, a sponginess about the early concentric layers, which, combined with the prevalence of star-shake, is very detrimental to the quality and usefulness of it; on this account it would be most suitable for such conversions as admit of its use in the greatest bulk.

Its employment being thus somewhat restricted, it will probably not be esteemed either among engineers or builders in this country.

TABLE LXI.—KAPOR OR CAMPHOR (BORNEO).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·08	3·75	1,213	910	1333	303·25
2	·60	·00	3·50	1,123	965	1149	280·75
3	·75	·05	3·75	1,168	1053	1109	292·00
4	·50	·05	4·00	1,236	977	1265	309·00
5	·65	·10	4·10	1,238	936	1323	309·50
6	·65	·00	3·50	1,127	895	1260	281·75
Total .	3·90	·28	22·60	7,105	5736	7439	1776·25
Average	·65	·046	3·766	1,184·16	956	1239·83	296·04

REMARKS.—All broke with splinters 4 to 8 inches in length.

TABLE LXII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	965	25,760	6,440
8		977	28,560	7,140
Total .	...	1942	54,320	13,580
Average	...	971	27,160	6,790

TABLE LXIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
21·75	21·25	21·00	21·25	85·25	21·31	5·33

E = 1,463000. S = 3108.

Borneo produces several other species of trees, including the Tanjan, Meraha, Mirabeau, Panjan, and the Kampar. These all attain good building sizes, and, judging from the sample logs sent with the Chow, &c., to this country, I am inclined to think they would be found useful and valuable for constructive purposes.

THE MOLAVÉ TREE (*Vitex geniculata**)

is found in the Philippine Islands, and, judged by the parcel of 6 to 8 loads of selected wood imported here in 1863 or 1864, is of straight growth and moderate dimensions, although, according to Blanco, it is "very often crooked."

* Blanco's "Philippine Flora."

The wood is yellowish or straw-colour, hard, heavy, strong, close in the grain, and possesses a figure or waviness that somewhat resembles satin-wood; hence it may be found useful not only in building, but for cabinet purposes. It is said to be used extensively in the Philippines for all kinds of work.

The Molavé timber appears to be of good quality, and has the property of seasoning without much shrinkage or splitting; it also stands exposure to the weather for a long time without showing any signs of being deteriorated by it. In the Philippines it is considered to be very durable.

Judging from the appearance of the parcel referred to, it can be recommended to notice, as being fit to supplement any of the hard woods in present use for constructive purposes.

TABLE LXIV.—MOLAVÉ (PHILIPPINE ISLANDS).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·10	5·00	1,200	972	1235	300·0
2	1·25	·25	5·75	1,320	987	1337	330·0
3	1·25	·15	4·75	1,210	1080	1120	302·5
Total .	3·75	·50	15·50	3,730	3039	3692	932·5
Average	1·25	·166	5·166	1,243·3	1013	1231	310·83

REMARKS.—Each piece broke with a long scarph-like fracture.

TABLE LXV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
4	2 × 2 × 30	987	30,240	7,560
5		972	29,120	7,280
6		1080	34,720	8,680
7		954	20,160	5,040
8		1115	42,000	10,500
Total . .	...	5108	156,240	39,060
Average .	...	1021·6	31,248	7,812

E = 832990. S = 3264.

The following woods are also found in the Philippine Islands, namely—

2. Lauan,
3. Banaba,
4. Dougon,
5. Ypil,
6. Lacolaco,
7. Acle,
8. Tindalo (two sorts),
9. Diladila,
10. Yacal,
11. Mangachapuy,
12. Karra,
13. Guigo,
14. Camayuan,
15. Malatapay,
16. Palo Maria,
17. Mapilia,
18. Mambog,
19. Bolongnita,

and some of them are considered to be of a very useful description, Nos. 2 and 7 especially so.

The Lauan timber (No. 2), after some experiments had been made on specimens 0·39371 inches square by 39·371 inches in length, with the following results, was

officially reported upon to the Spanish Government only a short time ago :—

TABLE LXVI.

Arc of flexion produced by a constant weight of 2,204 lbs. hung from the centre.	Arc at which fracture took place.	Weight applied at centre of the arc.	Distance between the supporters of the wood.
Inch.	Inches.	lbs.	Inches.
0·43	3·15	14·99	23·62 and 26·77

TABLE LXVII.

Weight of the specimen.	Resistance			Maximum elasticity to be allowed in construction of buildings.	Weight corresponding to this elasticity.	Strength of elasticity.	Resistance to tortion co-efficient of fracture T.	
	To pressure		Tension of strength of cohesion.				Absolute strength.	Applicable strength.
	With the grain of the fibre.	On the grain perpendicularly.						
lbs.	lbs.	lbs.	lbs.	Inch.	lbs.	lbs.	lbs.	lbs.
·948	498·24	198·41	1529·99	·038	152·99	158·16	168·43	16·84

REMARKS.—Weight producing fracture at the bend, 1·32 lb. T co-efficient of fracture by bending, or of maximum bend.

Father Gaspard de St. Augustine says, in his manuscript History of the Philippine Islands, that the outside planks of the old Manilla and Acapulco galleons were of Lauan wood, and that it was chosen because it does not split with shot.

THE ACLE, No. 7 (*Mimosa Acle, Fuga xylocropa*),* [illegible] is without thorns or excrescences. The Indians use it for the construction of their houses, and prize it for its good quality. In working it causes sneezing. The bark is

* Blanco's "Philippine Flora."

used in washing. Its leaves are not small like the generality of Mimosa, but about 8 or 9 inches long, by 3 inches broad. This wood is supposed to be identical with the Iron-wood or Pyengadu of Burmah.

The forests* of Panay (Iloilo) and Negros abound with these excellent woods, in situations most favourable for shipment.

* One of the present Chinese steam-frigates was built wholly of Philippine Island woods ; and the ribs, knees, &c., &c., were cut in the forests from templates sent from the Foo-choo-foo Arsenal.

CHAPTER XXIII.

AFRICA.

THE African Oak tree, the African Teak, or Mahogany timber of commerce—for it is known under a variety of names—is probably the *Swietenia Senegalensis*, or *S. Khaya*, the produce of which is brought from Sierra Leone, and appears to form a link between the Oak of Europe and America and the Teak of India, partaking largely of the characteristics of both species.

The tree is of straight growth, and the height, as estimated from the logs imported, must be at least 30 to 40 feet clear of the branches, with a circumference of from 7 to 8 feet. This wood is of a dark red colour, very hard, strong, rigid, and difficult to work or cleave; it has a fine, close, straight grain, is of remarkable solidity, has no injurious heart-shake, and shakes of the cup or star kind are extremely rare in it; the centre wood, about the earlier concentric circles, is close and very compact, differing less from the outer layers in texture than in most other trees. In seasoning this timber

shrinks very little, it rarely warps, and stands exposure to the weather a long time without opening with surface shakes, or sustaining any apparent damage.

African timber, possessing, as it does, so many good properties, is employed in ship-building for beams, keelsons, riding bitts, stanchions, &c., and in a variety of ways; but in civil architecture, and in the domestic arts, it is only sparingly used, on account of its weight.

This timber is brought upon the market in very roughly-hewn logs, intended, no doubt, to be square, but varying considerably from that form, and taking, generally, the most irregular shapes (Fig. 23). Some-

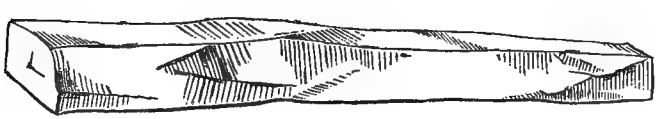

FIG. 23.

times they are angular, at other times they have a thick and a thin edge, resembling, in some degree, a "feather-edge" board; again, we find they are neither tapered to the natural growth of the tree, nor made parallel longitudinally, but vary in thickness in that direction, leading to a most serious waste of the raw material in the neglect to preserve the fullest-sized square log obtainable from the tree.

It will naturally be inferred that, being thus awkwardly shaped, it is the most difficult of all timber to measure correctly.

TABLE LXVIII.—AFRICAN (AFRICA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·25	·10	5·50	1,301	982	1325	325·25
2	2·50	·05	4·25	971	1086	894	242·75
3	2·50	·05	5·75	1,231	1008	1221	307·75
4	2·00	·00	5·35	1,086	988	1099	271·50
5	1·75	·00	4·75	1,014	934	1085	253·50
6	2·50	·10	5·25	1,046	962	1087	261·50
Total .	13·50	·30	30·85	6,649	5960	6711	1,662·25
Average	2·25	·05	5·142	1,108·16	993·3	1118·5	277·04

REMARKS.—Nos. 1, 3, and 4 broke with a long fracture; 2, 5, and 6, short, but fibrous.

TABLE LXIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the pieces broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	982	30,800	7,700
8		1008	43,400	10,850
9		934	19,040	4,760
10		962	19,600	4,900
Total . .	...	3886	112,840	28,210
Average .	...	971·5	28,210	7,052

TABLE LXX.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	5·013	18·625	39·5	64·0
15, 16	4·875	17·875	—	—
17, 18	4·875	18·500	—	—
19, 20	4·937	18·000	—	—
21, 22	4·875	18·500	—	—
23, 24	4·875	18·250	—	—
Total . .	29·450	109·75	—	—
Average .	4·908	18·292	39·5	64·0
Do. per in.	4·90	4·573	4·388	4·0

TABLE LXXI.

Vertical Experiments.

Number of the specimen.	Dimensions of the pieces.		Specific gravity.	Crushed with	Do. on the square inch.
	Inches.	Length. Inches.		Tons.	Tons.
25	2×2	1	993	17·000	4·250
26		2		18·292	4·573
27		3		18·875	4·719
28		4		18·125	4·531
29	3×3	7	. .	39·500	4·390
30		8	...	38·500	4·277
31		11	...	35·500	3·944
32		12	...	36·000	4·000
33	4×4	17	...	63·000	3·938
34	9×10	24	...	433·200	4·811

E = 410430. S = 2909.

We have no very extensive knowledge of the woods of Western Africa, and that to which I have just referred is probably the only useful tree known to commerce in the markets of this country. At the Cape I obtained specimens of the Else and Red Else wood, the light, dark, and grey Stink wood, and the Yellow wood, and understood that all these grew to moderate dimensions, and were useful for building and domestic purposes in the colony; but as there were none within easy reach of Cape Town, or then available for exportation, no opportunity was afforded of judging from any large parcel of either as to their real merits.

A few years since Mr. Macleod, formerly H.B.M. Consul at the Seychelles Islands, procured a great many specimens of woods from the district of the Zambesi, and sent them to the Admiralty.

Annexed is a list of twenty-six varieties, with their names and the dimensions the trees are supposed to attain, as also their uses as given by Mr. Macleod; observing that where an opinion of the quality is stated, it is the best that I could form from small pieces of $3'' \times 3'' \times 1''$.

Some few of these would certainly be fit for any architectural or other works, but we have no information as to their abundance or otherwise, or even whether they could be easily brought out from the forests to a port of shipment.

TABLE LXXII.

Trees found near the River Zambesi.

No.	Local Names.	Dimensions of Stem.		Remarks.
		Length.	Diameter.	
		Feet.	Inches.	
1	Inhanpasse . .	6	8	
2	Pingue or Pad-preto . . .	6	6	Resembles Lignum vitæ.
3	Mocua . . .	14	8—10	Forked knees. Good quality.
4	Imbila . . .	15—18	12	Flexible, light. Middling do.
5	Murumanhâma.	18	12	Pale red colour, light.
6	Mocunca. . .	15—18	8—10	Grows crooked, heavy.
7	Mocôza . . .	35—45	36—48	Yellow colour, light, wormed. Inferior quality.
8	Mucumite or Sandal-wood.	6—8	8	Brown with light and dark shades of colour, heavy, crooked. Good quality.
9	Pamburo. . .	Shrub		
10	Peam. . . .	18	12—20	Red colour, shrinks and warps, heavy.
11	Mussangara . .	12	10	Crooked, heavy, liable to split.
12	Taxa	20	20—28	Yellowish colour, heavy. Good quality.
13	Mocundo-cundo	36	40—60	Yellow colour, light, porous, used for masts, bark yields quinine.
14	Mucorongo . .	18	12	
15	Raiz-de-Pingue or Pao-preto.	...	...	Roots spreading, heavy, black as ebony.
16	Monangare . .	18	20—28	Resembles rosewood, heavy, crooked, used by wheelwrights, and for blocks.
17	Mocasso-cassa .	18	20—28	Reddish-brown colour, hard, heavy, used for joiners' work. Good quality.
18	Pao-ferra or Iron-wood .	24	8	Red colour, hard, heavy, used for furniture and treenails. Good quality.
19	Pao-ferro or Mais-is-curo .	24	8	Dark brown, heavy, resembles Sabicu. Good quality.
20	Pangira . . .	30	26	Brown colour, porous, used in house and ship-building.
21	Pao-fava. . .	22	12	Red colour, light, resembles mahogany. Good quality.
22	Metteral. . .	24	12	Ditto, heavier. Ditto, ditto.
23	Mugunda . .	40—60	12—24	Yellow colour, straight, light, used in ship-building.
24	Morrunda . .	15	5—8	Ditto, ditto, ditto.
25	Mouna . . .	15	12	Red colour, straight, moderately heavy. Good quality.
26	Luabo . . .	12	10	Ditto, heavy, ditto.

CHAPTER XXIV.

WEST INDIES, ETC.

THE Greenheart tree, *Nectandra Rodiæi*, belonging to the natural order *Lauraceæ*, is found in Guiana, in the north-eastern portion of South America, and is an exceedingly valuable tree, yielding timber of perfectly straight growth, of from 24 to 50 feet in length, and 12 to 24 inches square.

Dr. Rodie detected in the bark of this tree an alkaloid called Bebeerine, which is used by the inhabitants of British Guiana as a remedy for fevers; and it is said, that when used as a substitute for quinine, it does not produce the headache and other symptoms found to follow the use of that medicine.

The wood is of a dark greenish or chestnut colour, the centre part being often nearly black; it, however, varies slightly, and the darker kinds are considered the best in quality. It is clean and straight in the grain, very hard and heavy, tough, strong, and elastic. In a transverse section it resembles a cane in being very full of minute pores, and the concentric layers are only in rare instances distinguishable.

The heartwood is considered very durable, and is generally believed to be proof against the ravages of the worm when used for piles, or other purposes under water, a property which would greatly enhance its value if it could be relied upon; but its immunity under such circumstances is thought to be doubtful.

Of the durability of the Greenheart timber, we have had sufficient evidence in the large stock of this wood kept in the royal dockyards, where it stood the test of many years' exposure to the weather, without being in any but the least degree affected by it. At Woolwich, the only place, I believe, where any attempt was made to protect it for preservation, the experiment to some extent failed, the ends of the logs splitting open rather more in the covered stacks than in those which were left exposed, while, in other respects, there was absolutely no difference observable between the two parcels.

It is characteristic, however, of the Greenheart timber to split in this way, and to open clean across the pith in seasoning, there being frequently two such splits crossing each other at nearly right angles, and cleaving the log, at the end, into four segments; but these do not, usually, extend more than two or three feet up from the end.

This serious defect is, to some extent, compensated for by the fact that the logs do not split and form deep shakes along the sides in the seasoning, as do most other woods; so that there is not, after all, more than the ordinary amount of waste in the conversion of this kind of timber. Further, it is remarkable for its freedom from knots, and also for its general soundness, the only defect, beyond the splitting of the ends before mentioned, being a cross fracture of the longitudinal fibres, which is occasionally seen, but can seldom be detected before the log is under conversion.

The alburnum, or sap of this wood, is of a dark greenish colour, and differs so little in appearance from the heartwood, that it is often difficult to distinguish the one from the other. In quantity it is usually excessive, frequently amounting to a fifth, and sometimes even to a third, of the diameter of the tree. Few people, however,

regard it when appropriating this timber to works of construction.

Owing to the difficulty of distinguishing the sap, many either dispute its presence altogether, or assert that if it exists it may be safely employed the same as the sap of Lignum Vitæ; this is, however, by no means certain, as I have found that if it is placed in any damp or imperfectly ventilated situation, it decays much sooner than the heartwood; but, if used under more favourable circumstances, its durability is very great.

In connection with this question, a merchant and importer of Greenheart timber said upon one occasion, when we had a parcel under survey, that he was confident a certain log had no sapwood upon it, for if it had, it would be liable to the attack of a small worm, but that the worm would not touch the heartwood. The log referred to was accordingly tested by cutting off a thin cross section, and upon examination of the piece, there were found in it several marks or traces of the worm, which had penetrated to the depth of 2 to 3 inches; the heartwood, or duramen, had not, however, been touched. The gentleman at once admitted that, with such evidence, he would take it as conclusive that there was sap to the depth of 3 inches on the log, but that its appearance had entirely deceived him.

The case was no doubt exceptional, as the worm is very seldom seen in this wood.

Greenheart is extensively employed in ship-building for keelsons, engine-bearers, beams, shelf-pieces, &c., and for planking. It is also used for piles, and many other purposes, but its application to the domestic arts is somewhat limited by its great weight.

The strength of this wood exceeds that of most others, whether it be tried by the transverse or tensile

strain, or by a crushing force in the direction of its fibres. Tried by the latter process, it exhibits a peculiarity unshared, I believe, by any other timber except Sabicu. It bears the addition of weight after weight without showing any signs of yielding; and, when the crushing force is obtained, it gives way suddenly and completely, with a loud report, nothing being left of the pieces but a loose mass of shapeless fibres.

The Greenheart timber is not usually hewn in the perfect manner that Teak, Mahogany, and many other woods are when prepared for shipment to the markets of this country, but comes from Demerara only partially dressed, a great deal of wane being left upon the angles. The butts are also almost invariably left with the snapped ends, as prepared for drawing out of the forest, instead of being cut off square. Its form should therefore be considered with the price quoted per load, as it will not compare favourably with well-squared timber.

TABLE LXXIII.—GREENHEART (DEMERARA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·15	·05	5·00	1,235	1180	1047	308·75
2	2·00	·00	4·75	1,656	1193	1388	414·00
3	2·25	·15	4·60	1,305	1079	1209	326·25
4	2·00	·00	5·00	1,212	1152	1052	303·00
5	2·25	·15	4·15	1,258	1172	1073	314·50
6	2·25	·05	4·25	1,329	1122	1184	332·25
Total .	12·90	·40	27·75	7,995	6898	6953	1998·75
Average	2·15	·066	4·625	1,332·5	1149·6	1158·8	333·125

REMARKS.—Nos. 1, 2, 3, and 6 broke with splintery fractures, 12 to 15 inches in length; 4 and 5 with similar fractures, but only 10 to 12 inches in length.

TABLE LXXIV.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1152	31,920	7,980
8		1079	36,400	9,100
9		1193	37,520	9,380
Total . .	...	3424	105,840	26,460
Average .	...	1141	35,280	8,820

TABLE LXXV.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
10—13	7·00	27·000	57·125	93·150
14—17	6·75	27·362	58·000	92·875
18—21	6·75	27·750	57·250	92·625
22—25	6·50	27·000	56·875	93·500
Total . .	27·00	109·112	229·25	372·150
Average .	6·75	27·278	57·312	93·037
Do. per in.	6·75	6·819	6·368	5·814

TABLE LXXVI.

Vertical Experiments.—Four pieces, Nos. 26, 27, 28, *and* 29, *each* 2 × 2 *inches, and respectively*

	1	2	3	4	Inches in length.
Crushed with	27·25	27·2875	25·875	25.862	Tons.

E = 436880. S = 3498.

THE MORA TREE (*Mora excelsa*),

the produce of Demerara and the island of Trinidad, is a tree of straight growth, yielding timber in the log of 18 to 35 feet in length, and 12 to 20 inches square.

The wood is of a chestnut-brown colour, hard, heavy, tough, strong, and generally straight in the grain, but has occasionally a twist or waviness in the fibre, which imparts to the logs possessing it a beautifully figured appearance, giving to them much additional value. As it takes a good polish, it would be useful as a substitute for Rosewood, or dark Spanish Mahogany in cabinet making, and might be employed for many purposes in the domestic arts.

The economical uses of the Mora are somewhat restricted by the frequency of star-shake in the logs, and only the best trees can be advantageously converted into plank and board; it may, however, be used with greater profit for beams, keelsons, engine-bearers, &c., in ship-building, and in a general way in large scantlings for either civil or naval architecture.

The Mora possesses great strength, and contains an oily or glutinous substance in its pores, which is probably conducive to its durability.

TABLE LXXVII.—MORA (DEMERARA AND TRINIDAD).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·00	·10	4·75	1,353	1075	1258	338·25
2	2·00	·10	5·00	1,363	1088	1253	340·75
3	2·15	·15	5·00	1,304	1094	1192	326·00
4	2·00	·05	5·00	1,284	1090	1178	321·00
Total .	8·15	·40	19·75	5,304	4347	4881	1326·00
Average	2·037	·10	4·94	1,326	1086·75	1220·25	331·5

REMARKS.—Each piece broke with about 12 inches length of fracture.

TABLE LXXVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
5	2 × 2 × 30	1094	37,800	9,450
6		1090	37,240	9,310
7		1075	35,840	8,960
Total .	...	3259	110,880	27,720
Average	...	1086	36,960	9,240

TABLE LXXIX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
14·875	14·750	14·875	15·750	15·750	15·500	91·50	15·25	3·812

E = 466570. S = 3481.

The island of Trinidad also produces the Carapo and the Balata trees, both of which attain moderate dimensions.

Sample logs of the Carapo timber were a few years since sent to Woolwich Dockyard, with a view to their introduction for ship-building purposes. The wood was red in colour, straight in the grain, of moderate weight and hardness, and somewhat resembled inferior mahogany.

It had, however, a strong tendency to split and tear to pieces in seasoning, and in only a few months it was so far deteriorated by shakes as to be unfit for almost any purpose in carpentry.

The wood of the Balata tree was dark red in colour—fine, close, and straight in the grain—hard, heavy, strong, and somewhat resembled the African timber of commerce, except that the centre of the logs was very shaky. Decay, with hollowness, had set in about the pith in some of the logs, indicating that it had commenced while the trees were still young, and otherwise strong and vigorous.

When the logs referred to had been kept for only a few months to season, the ends split open very much, and as these splits or shakes crossed each other at nearly right angles, and extended rapidly, they seemed likely soon to separate the pieces into four quarters, a serious defect which disqualified them for use in large scantlings, and rendered them only fit for some inferior purposes.

Judged by the samples of Carapo and Balata, it seems that neither are suitable for important works of construction; it is therefore doubtful whether any supplies will be now imported.

The following woods, the growth of French Guiana, were selected under a commission appointed by the

Colonial Government of St. Laurent du Maroni. They were imported into Havre only recently (1874).

1. Angélique. A species of Teak. This tree is of straight growth, and yields timber 12 to 22 inches square, by 20 to 54 feet in length, clear of branches.

The wood is of a reddish-brown colour, clean and even in the grain, moderately hard, tough, strong, elastic, and not difficult to work, although it does not cleave readily. Occasionally a few logs are found with a waviness or figure in the grain, which would make them valuable to the cabinet-maker. There is little sap-wood.

The timber is very sound and free from knots, and, except that a small percentage of the logs have a slight heart, or perhaps, star-shake at the pith or centre, there are no defects affecting the conversion of it into planks, boards, &c., as may be required. This wood, therefore, seems fit for employment in architecture for most of the purposes to which African, Mahogany, Oak, Teak, Sabicu, &c., &c., are used.

It is reported to have been used for some time in the French dockyards as backing to armour plates on ships, and as it does not appear to contain any acid, it might be employed in lieu of Teak for a similar purpose in the royal dockyards in England. It has been said that it does not rot in water, that it is proof against attacks from many insects to which other timber is liable, and that it is durable. The specific gravity is estimated to be about 770 to 820 when seasoned.*

* Since the above was written, an opportunity has offered of practically testing a few logs of partially seasoned Angélique timber, s. g. 916. They opened very sound, and were tough, strong, and elastic. There was very little waste in the conversion—in reducing it to planks, &c. In working, however, it was found that some of the logs emitted an unpleasant odour, and—unless in seasoning the odour should evaporate—this may possibly prove detrimental to its value for general purposes, perhaps for the inside of ships, or in close, damp places.

2. Balata. This wood is of a yellowish colour, hard, heavy, strong, plain in grain, with slight heart-shake at pith or centre. It appears to be of good quality, and fit for employment in architecture in lieu of other hard wood, or it might be used for furniture. The sample logs were 13 to 18 inches square, by 20 to 24 feet in length.

3. Ébène, This wood is greenish in colour, very hard, heavy, strong, plain and even in the grain, solid, and good in quality. The sap-wood is about 1½ inch thick. It would be useful in turnery, or for any of the purposes to which the common or Ceylon Ebony is applied.

4. Ébène rouge. This wood is of a dark reddish colour, hard, heavy, strong, and straight in the grain, but is scarcely so solid at the centre as the last-mentioned wood. The dimensions of two sample logs were 12 to 14 inches square, by 14 to 17 feet in length. Both had cup-shakes at the ends. The uses for this wood would be similar to No. 3.

5. Grignon. This wood is red in colour, moderately hard, close and plain in the grain, and solid. It is of good quality, and fit to be employed in civil architecture, or in the domestic arts. The dimensions of sample logs varied from 14 to 17 inches square, and 14 to 27 feet in length.

6. Maconatari. Only one out of six pieces sent could be identified; it was dark in colour, hard, and heavy. The dimensions given for the parcel varied from 14 to 20 inches square, and 14 to 23 feet in length.

7. Paccouri Soufri. This wood is of a reddish-yellow, or brimstone colour, of a moderate degree of hardness, straight in the grain, and disposed to split freely in seasoning. Three logs were sent as samples, and each had injurious heart and cup-shakes. The

dimensions were 19 to 22 inches square, and 14 feet in length: longer timber could no doubt be obtained if it were worth while, but it seems to be only fit for very inferior purposes.

8. Rose mâle. This wood is of a yellowish colour, moderately hard, heavy, and straight in the grain. Only one sample log was sent; the dimensions were 12 inches square, and 14 feet in length, both ends were covered with wood clamps, which was probably done to hide a faulty centre. It appeared to be only fit for inferior purposes.

9. Rose femelle. This wood, like the preceding, is of a yellowish colour, hard, of moderate weight, and straight in the grain. Only one sample log was sent; the dimensions were 16 inches square and 14 feet in length, and this was touched with incipient decay at the centre. Like No. 8, it appeared to be only fit for inferior purposes.

10. Simarouba. This wood is light in colour, moderately hard, plain and free in the grain, and splits rather seriously in seasoning. The quality is not good, it therefore could only be used for inferior purposes. The dimensions of the logs varied from 14 to 16 inches square, and 13 to 14 feet in length.

11. Satiné. This wood is red in colour, hard, heavy, solid, and of good quality. It might be employed in either naval or civil architecture in lieu of other hard wood, and also for cabinet work, turnery, &c., &c. The dimensions of the logs varied from 13 to 15 inches square, and 14 to 28 feet in length. The sap-wood left upon the angles appeared to be about 1½ inch thick.

12. St. Martin. This wood is red in colour, hard, heavy, close and straight in the grain, and of good quality. It might be employed in either naval or civil architecture in lieu of other hard wood, and would be valuable for furniture and other purposes. The dimensions of the

two sample logs were 17 and 20 inches square, and 27½ feet in length.

13. Violet. This wood is of a violet colour, very hard and heavy, close and fine in the grain, and solid. The quality is very good, and therefore it is likely to be highly prized by the cabinet-maker, turner, and others. The dimensions of the logs were 11 and 13 inches square, and 24 feet in length.

14. Wacapou. This wood is brownish in colour, straight, and clean in the grain, of moderate hardness and weight, and inclined to split or shake rather seriously from the pith or centre. It would not, therefore, be of much value for architectural purposes, but in the domestic arts it could be turned to account in many ways. The dimensions of the logs varied from 13 to 16 inches square, and from 14 to 21 feet in length.

15. Wacapou gris. This wood is darker in colour than the preceding, and has a slight resemblance to Rosewood, but is upon the whole pretty much of the same character as the Wacapou, and of no value except perhaps for the plainer description of cabinet work. The dimensions are the same as No. 14.

16. Ébène verte. This wood is dark green in colour, very hard, heavy, close in the grain, solid, and of good quality. Like No. 3, it has about 1½ inch of sap-wood. The dimensions of the logs varied from 14 to 16 inches square, and were about 14 feet in length. It would be chiefly useful in cabinet work and turnery.

17. Boco. This wood is dark in colour, hard, heavy, straight, and of good quality. It might be useful in architecture as an article of general applicability in place of other hard and strong wood, or to the cabinet-maker for furniture, &c., &c. The logs were delivered at the docks in Havre in a round state, and were about 18 inches in diameter, and 29 feet in length.

18. Panacoco. This wood is dark in colour, hard, heavy, straight, and of good quality, the sap-wood being about 1⅝ inch thick. It might be used as a substitute for other hard wood in architecture, or for general purposes. The sample log was in a round state, 17 inches diameter, and 32½ feet in length.

All the woods, from 2 to 18 inclusive, were readily taken by the Parisian and local dealers at Havre for cabinet and other purposes, and realised good prices.

A great many specimens of other woods growing in the French colony at Guiana were also sent with the foregoing; but as they were quite small pieces it was difficult to judge of their fitness for employment in architectural or other works. Probably before long some of these may be supplemented by sample logs, similar in dimensions to Nos. 2 to 18, and if so, a better estimate may be formed of their commercial value.

THE JUBA TREE (*Erythroxylon*)

is found in Havana. Two sample pieces of plank, cut from the Juba tree, were sent by the Consul-General in Cuba, in 1858, to the Admiralty, with a view to the introduction of this wood into the royal dockyards for ship-building purposes.

It was understood they were forwarded at the request of Mr. Donald, a gentleman of considerable experience in the timber business, who was of opinion that it would be found a useful wood. He reported that the tree attained the same dimensions as the Sabicu, and that it could be supplied in large quantities. It, therefore, appeared to be well worth a consideration, as the importation of Sabicu timber was very limited, and scarcely equal to the demand for it.

The samples referred to, upon examination at Wool-

wich, were found to have been cut from small trees, but so far as could be judged from their appearance, the timber was suitable for use in architecture, and would probably be useful in the domestic arts.

The wood of the Juba tree is yellow in colour, hard, heavy, strong, close in the grain, and apparently would work up well. The specific gravity is about 1072.

I have not been able to ascertain that it has ever been brought upon the London market, and think it likely its uses are chiefly confined to the island of Cuba.

THE SABICU TREE (*Acacia Formosa*)

is a native of the West Indies, and is plentiful in Cuba. Its growth is somewhat crooked and irregular, but it yields excellent timber of from 20 to 35 feet in length, and from 11 to 24 inches square.

The wood is of a dark chestnut colour, hard, heavy, strong, close in the grain, and is often twisted or curled in the fibres, which gives it a wavy, or, as it is technically termed, a figured appearance, imparting to it a rich dark colour, which resembles and is sometimes mistaken for Rosewood. It is often on this account of considerable value, and being capable of taking a high polish, is much prized by cabinet-makers and others, who employ it for furniture, &c.

The Sabicu has very little sap, and is a remarkably solid wood. It is characteristic of it that there is an almost complete absence of the heart, star, and cup-shakes. It seasons slowly, shrinks but little, and does not split, as do most other woods, while undergoing that process. It also bears exposure to the weather without being in any but the slightest degree affected, even if left without either paint or varnish to

protect it; further, it works up well, and there is only a trifling loss in its conversion. Therefore, as this wood is known to be durable, it has much to recommend it to the favourable notice of the manufacturer.

There is one defect, however, occasionally met with in the Sabicu, which must be set against the good qualities before mentioned, as it is more common to this than to any other timber with which we are acquainted. This is a cross fracture of a very remarkable kind, and of the greatest importance, from the fact that it can rarely be detected until the log is in process of conversion. It is then sometimes found that the longitudinal fibres of the early and middle period of the tree's existence are completely broken, while the outer woody layers of both the duramen and alburnum are perfect. This defect will sometimes occur in several places in the same tree.

It is difficult to conjecture the cause of this, since it cannot, one would think, be done by the concussion in the fall of the tree, as that would, if any injury were done, produce a more extensive fracture than has been noticed; one which would be apparent upon a superficial examination of the surface. I therefore incline to the opinion that it is produced by the storms and hurricanes that occasionally sweep over the island, swaying the trees to and fro, and snapping the longitudinal fibres of the stem, without breaking them completely off; the later growth apparently strengthening, and most effectually covering the defect.

It may, however, be well to state, that in offering this opinion of the cause of the cross fracture in Sabicu timber, the same does not appear to affect the Mahogany and other trees, the produce of Cuba, since no instance of this peculiar defect has been found.

Sabicu is used in ship-building for beams, keelsons, engine-bearers, and stern-posts, and for pillars, cleats, &c.

Officers have, however, hesitated to employ it for beams which are intended to carry heavy guns, lest it should contain some hidden defect of the character just mentioned. It is only sparingly used in works of civil architecture, on account of its great specific gravity.

TABLE LXXX.—SABICU (CUBA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·00	·00	3·25	1,090	936	1165	272·50
2	1·00	·10	4·10	1,510	928	1735	377·50
3	1·00	·05	3·15	1,090	899	1213	272·50
4	·85	·00	4·25	1,390	910	1527	347·50
5	1·00	·05	3·50	1,280	923	1387	320·00
6	·90	·00	4·25	1,395	904	1543	348·75
Total .	5·75	·20	22·50	7,755	5500	8570	1938·75
Average	·958	·033	3·75	1,292·5	916·66	1428·33	323·125

REMARKS.—Nos. 1, 4, 5, and 6 broke with about 10 to 11 inches fracture; 2 and 3 broke with 8 inches fracture.

TABLE LXXXI.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	923	17,360	4,340
8		904	24,360	6,090
9		910	22,120	5,530
10		936	21,280	5,320
11		899	20,776	5,194
12		928	27,496	6,874
Total . .	...	5500	133,392	33,348
Average .	...	916·66	22,232	5,558

TABLE LXXXII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	3·000	15·875	36·625	61·75
17—20	3·250	16·750	36·500	63·75
21, 22	3·125	16·000		
23, 24	2·875	14·750		
Total . .	12·25	63·375	73·125	125·50
Average .	3·062	15·844	36·562	62·75
Do. per in.	3·062	3·961	4·06	3·922

E = 972320. S = 3393.

THE LIGNUM VITÆ TREE (*Guaiacum*)

is found on several of the West India Islands, and in many other places, but the chief supplies come from St. Domingo and Bahama. It attains, in the former, the diameter of 22 inches, and some 30 to 40 feet in length; but the Bahama is generally very small.

The wood is dark brown, or rather greenish black, in colour, very hard, heavy, strong, and close and wiry in the grain; it is difficult to work in any fashion, but there is nothing equal to it for the making of sheaves for blocks, and when employed in this way it wears well, and seems almost imperishable. I have examined some sheaves after they had been in use for 50 to 70 years, and found them perfectly good, and fit for further service.

The sap-wood is yellow in colour, ¾ to 1 inch in thickness, and, like the sap of English Elm, is of such exceptionable character, that it is equally as good and durable as the heart-wood. In sheave making, a belt of

this sap-wood is, if possible, left on to preserve the rest of it from splitting. The chief defect in Lignum Vitæ is the cup-shake, and this occurs rather frequently in the wood of 10 inches and upwards in diameter; it is, therefore, often difficult to obtain a sufficient supply of the larger sizes suitable for the block-maker, who must have not only the roundest, but also the most solid, wood for his purpose. There are many demands, however, for this wood for less important services, and all that comes finds a ready sale.

Lignum Vitæ is imported in the round state, and in very short lengths; pieces under 10 inches diameter are usually in lengths of 6 to 12 feet, and the larger wood in lengths of 3 to 6 feet. It is commonly sold by weight, and realises from £6 to £18 per ton, according to size and quality. That from the city of St. Domingo is the best. The specific gravity is 1248.

THE ROSEWOOD TREE (*Triptolomea*)

is found in Jamaica, Honduras, Bahia, Rio, and San Francisco. It attains large dimensions, but is often faulty in the centre, owing to decay setting in long before the tree reaches maturity.

The wood is dark chestnut, or brown, in colour, streaked or veined, and generally figured in the grain; it is hard and heavy, but in the hands of the cabinet and pianoforte makers it works up well; it is highly valuable for all kinds of ornamental work, and for many purposes in the domestic arts. It takes a good polish.

The chief defect in this wood is heart-shake, or hollowness at the centre, which extends far up the tree, and this necessitates the cutting of the logs down the middle longitudinally; often a middle piece is wasted on this account, consequently we never see sound solid

square logs, or even plank, but generally half-round flitches, 10 to 20 feet in length, and varying from 5 to 12 inches in the thicker part, put upon the market, the inside or sawn surface being even then frequently deficient of wood in the centre, exhibiting in part the hollowness pertaining to the tree.

Solid round Rosewood logs beyond the medium size, or 14 inches in diameter, are extremely rare, and the best that I have met with were brought from San Francisco. Owing to the difficulty there is in measuring half-round flitches of the nature and form herein described, this wood can only be sold by weight. It realises, for the inferior, £10 to £12, and for the good, £20 to £30 per ton; the superior qualities fetch much higher prices.

CHAPTER XXV.

WEST INDIA AND CENTRAL AMERICA.

MAHOGANY, SPANISH (*Swietenia*),

Is the produce of the island of Cuba, and is indiscriminately called the Spanish or Cuba Mahogany. It is a tree of perfectly straight growth, and yields timber for the market of from 18 to 35 feet in length, by from 11 to 24 inches, dressed quite square, and generally with two or three stops or joggles, with the view to preserve as much timber as possible in the stem of the tree. (*Vide* Fig. 24.)

FIG. 24.

The wood is of a reddish-brown colour, hard, heavy, strong, close and straight in the grain, with occasionally a wavy or figured appearance; it is also very solid, especially about the centre, or pith, the heart-shake in this variety of the Swietenia being quite insignificant; the cup and star-shakes are also rare, and there is little sap-wood; so that it need not give us any anxiety in dealing with it, whatever may be the nature of the conversion required. It is susceptible of a very high polish, and with the wave or figure well marked, it possesses

great beauty; indeed, if worked up for furniture, or used for any ornamental purposes whatever, we cannot fail to admire it. The figured logs, therefore, possess a considerably enhanced value over those of a plainer description, and high, even fabulous prices are often realised for them.

Cuba or Spanish Mahogany is durable, and is employed for a variety of purposes. It has been very advantageously used in the building of ships of war in place of Oak for beams, planking, stanchions, &c.; its strength and rigidity rendering it admirably fitted for these, while, being of moderate specific gravity, it was safe to use it either above, at, or below the line of flotation; but in civil architecture it is not much used, on account of the high price it obtains over other woods.

TABLE LXXXIII.—MAHOGANY (CUBA, OR SPANISH).

Transverse Experiments.

Number of the specimen.	Dimensions.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 700.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·50	·00	3·50	767	720	746	191·75
2	1·50	·00	3·50	883	817	757	220·75
3	1·25	·05	3·50	817	789	725	204·25
4	·85	·00	3·85	956	752	890	239·00
5	1·15	·05	3·35	883	765	809	220·75
6	1·00	·05	3·00	831	771	763	207·75
Total .	7·25	·15	20·70	5,137	4614	4690	1,284·25
Average	1·208	·025	3·45	856·16	769	781·66	214·04

REMARKS.—Nos. 1 and 4 broke with moderate length of fracture, and splintery; 3, 5, and 6—each broke very short.

TABLE LXXXIV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	752	19,040	4,760
8		765	19,824	4,956
9		817	15,120	3,780
10		720	11,200	2,800
11		771	10,640	2,660
Total . .	...	3825	75,824	18,956
Average.	...	765	15,165	3,791

TABLE LXXXV.

Vertical Experiments on cubes of—

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	2·500	12·750	27·250	38·750
16—19	2·750	11·875	27·375	39·150
20—23	2·875	13·625	26·800	38·625
24—27	2·875	13·750	27·425	39·100
Total . .	11·000	52·000	108·85	155·625
Average .	2·750	13·000	27·212	38·906
Do. per in.	2·75	3·25	3·024	2·431

NOS. 28 TO 36.—Four more pieces—each 2 × 2 × 2 inches—tried under the vertical pressure, took, on the average, 13·937 tons, or 3·484 tons to the square inch, to crush them. Two pieces, each 3 × 3—the one 11 inches, the other 16 inches in length—bore 27· tons and 25·5 tons. Two other pieces, each 4 × 4 inches—the one being 8 inches, the other 13 inches in length—bore respectively 47·75 tons and 38·5 tons; and one piece—12 × 12 × 15 inches in length—bore 481 tons, or 3·34 tons per square inch of base.

$$E = 771030. \qquad S = 2247.$$

THE ST. DOMINGO MAHOGANY TREE (*Swietenia*)

is very similar in quality, but of much smaller dimensions than that of Cuba, and only a few logs exceeding 8 to 10 feet in length, by 12 to 13 inches in the mean thickness of their scantlings, are imported into the markets of this country, although they are occasionally seen in well-squared logs, measuring $15'' \times 15'' \times 25'$.

The wood is of a deep red colour, hard, almost horny, heavy, strong, and very solid at the centre; it has a good figured grain, and near to the top of the stem, where it branches off, there is generally a rich and pretty feather or curl in it, which is much prized by cabinet-makers, especially when it is of sufficient length for table-tops, or the fronts of drawers. It shrinks very little, and rarely splits externally in seasoning.

The average measurement of the logs imported is only about 100 superficial feet of 1 inch; while the pieces brought over as curls are seldom more than about 12 superficial feet. Owing to the very small dimensions of this Mahogany tree, there is scarcely any that is available for architectural works, and the supply which comes to us goes solely to meet the demand for cabinet and ornamental purposes.

THE NASSAU MAHOGANY TREE (*Swietenia*).

This is even more dwarfish in character than the Mahogany of St. Domingo, and the logs imported have rarely exceeded 5 or even 3 feet in length, dressed into neat squares of 6 to 12 inches, the latter size being, however, rare. The measured contents of these logs average only about 8 to 9 superficial feet of 1 inch thick.

The wood is deep red in colour, hard, heavy, equally

horny with the St. Domingo Mahogany, very firm and solid at the centre, fine and close in texture, and is generally veined or figured, or in curls; hence it is very suitable for cabinet work in a small way and for turnery.

THE HONDURAS MAHOGANY TREE (*Swietenia*).

This tree, which was formerly found in great abundance in the forests of Central America, near to Belize, was first imported into England about 1724 or 1725; the supply is, however, gradually failing; but until quite recently it has been brought in sufficient quantities, annually, to meet the requirements of this country; it is therefore well known to commerce as a most valuable wood for furniture purposes.

In contrast with the two species last mentioned, these Mahogany trees of Honduras are very tall, and rise 40 to 50 feet to the branches, with a circumference of 6 to 9 feet; they are generally straight, but are not unfrequently of an irregular or crooked growth; they yield very fine logs of 25 to 40 feet in length, by 12 to 24 inches square, and some are occasionally met with of much larger dimensions; but even this does not show, fully, the length of useful wood in this noble tree, since we learn from those engaged in the trade that each tree is cut several feet up from the ground, and that in this way is involved a very unnecessary amount of waste of a most valuable article.

The wood is red in colour, moderately hard, strong, tough, flexible and elastic while fresh, but becomes somewhat brittle when thoroughly dry; it has a smooth, silky grain, works up well, and does not shrink or warp much in seasoning; it is liable, however, to split into deep shakes, externally, if this process is carried on too rapidly. The quality of the wood varies very much,

according to the situation in which it is grown; that which is produced on a firm soil and in exposed places, and notably that grown in the northern district, being by far the best, while the timber produced on the low moist grounds is generally soft, spongy, and inferior. For the most part, however, it is of a very plain character, with uniformity of colour, although occasionally logs are found with a waviness or curl in the grain, approaching to figure; and these, when worked up and polished, present an appearance of great beauty; such logs generally realise, as in the case of Cuba Mahogany, a much higher price than logs of the ordinary description, which fetch at present market prices (1875) about 4½d. to 6d. per foot superficial of 1 inch. About two-thirds only of the actual cubic contents, calliper measure, are, however, brought to sale account. The remainder or difference being allowed for the waste of saw kerfs, shakes, defects, centres, &c., in the conversion of the log into board, &c.*

The economical uses of this wood are very numerous, and it is much sought after by shipwrights, carpenters, cabinet-makers, turners, and others, who employ it for a great variety of purposes. It has been largely used in ship-building for beams, planking, and in many other ways as a substitute for Oak, and found to answer exceedingly well. It is also used extensively for cabin-fitments; and in its application to the arts there is scarcely any limit to its usefulness.

The Honduras and other descriptions of Mahogany have only about ¾ to 1 inch of alburnum or sap-wood on them, and being remarkably free from defect, the loss in conversion is comparatively small.

* This mode of measurement applies equally to all the other descriptions of Mahogany, and to Cedar.

TABLE LXXXVI.—MAHOGANY (HONDURAS).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 700.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·00	·10	4·50	811	644	881	202·75
2	1·75	·00	3·75	821	684	840	205·25
3	2·25	·10	3·75	750	650	808	187·50
4	2·00	·05	3·55	756	662	799	189·00
5	1·65	·10	4·15	823	650	887	205·75
6	1·85	·15	4·65	851	666	894	212·75
Total .	11·50	·50	24·35	4,812	3956	5109	1203·00
Average	1·916	·083	4·058	802	659·3	851·5	200·5

REMARKS.—Each piece broke with moderate length of fracture, and splintery.

TABLE LXXXVII.

Tensile Experiments.

Number of the specimen.	Dimension of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2×2×30	662	10,920	2,730
8		650	12,040	3,010
9		644	9,940	2,485
10		666	14,280	3,570
11		684	12,740	3,185
12		650	12,040	3,010
Total. .	...	3956	71,960	17,990
Average.	...	659	11,993	2,998

TABLE LXXXVIII.

Vertical or Crushing Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	2·675	11·00	27·75	45·000
17—20	3·000	11·00	27·00	45·500
21—24	2·675	11·25	26·875	44·875
25—28	2·875	10·75	27·875	45·125
Total . .	11·225	44·00	109·500	180·500
Average .	2·806	11·00	27·375	45·125
Do. per in.	2·806	2·75	3·042	2·820

Nos. 29 and 30.

	Crushed with the weight of	
One piece, 9″·5 × 9″·5 × 15″,	307 tons	= 3·493 tons per square inch.
,, 9″·5 × 9″·5 × 18″,	336·8 ,,	= 3·833 ,, ,,

$E_1^1 = 492550.$ S = 2105.

THE MEXICAN MAHOGANY TREE (*Swietenia*)

is the produce of Mexico, in Central America, where it is very abundant. It is of straight growth and outvies every other description of mahogany in its noble dimensions. It yields the timber of commerce in squares of 15 to 36 inches, by 18 to 30 feet in length. These are, however, only the ordinary lengths brought to market, the stems being generally cut into short pieces for the convenience of getting them down the hatchways of the ships, which have frequently to load in a roadstead, where it would be unsafe to open a raft-port.

Some of the trees from the district of Minatitlan must be very large, since it is no unusual thing to meet with well-squared pieces of this timber, measuring 40 to

48 inches on the side, with every appearance of having been cut from tall trees. Hence we infer that in their growth they must exceed the height of those grown in Honduras.

The wood is red in colour, moderately hard, less strong, and with the centre more soft, spongy, and shaky than either of the varieties before referred to. Exception may, however, be taken in favour of Tabasco; the districts of Frontera, Chiltepec, Santa Ana, and Tonala, each yielding some very excellent timber.* The grain of the Minatitlan is generally very plain, but that cut in the province of Tabasco has generally some rowiness or figure to recommend it for special purposes. It is easy to work, takes a good polish, splits very little, and stands well after it is seasoned. It is tough and elastic while quite fresh, but brittle when thoroughly dry, breaking off short if subjected to a heavy strain.

The chief defect in Mexican Mahogany is the prevalence of star-shake, and this, combined with the spongy character of the early layers, or centres, of many of the trees, frequently spreading, as they do, over about one-sixth of their diameter, detracts very much from their usefulness; but, as this can all be seen by examining the ends, the converter will naturally select and appropriate the logs to the work he may have in hand, and thus avoid any serious loss.

The Mexican Mahogany is generally too large and heavy in growth to be converted profitably to ship scantlings, but is in other respects a very good substitute for Honduras for all kinds of joiners' and cabinet work,

* Mexican is sold in the London market at about the same price as Honduras Mahogany; but the cuttings from Tabasco often realise fully 20 per cent. more.

and is used most extensively in that way. It therefore supplements the supply of Honduras, the deliveries of which of late have been scarcely sufficient to meet the growing demands for it.

TABLE LXXXIX.—MAHOGANY (MEXICAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 700.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·00	3·50	720	790	638	180·00
2	1·25	·10	4·25	700	612	801	175·00
3	1·00	·05	4·25	920	715	901	230·00
4	1·00	·00	3·65	785	665	841	196·25
5	1·25	·15	3·75	880	660	933	220·00
6	1·00	·05	4·15	690	625	733	172·50
Total .	6·75	·35	23·55	4,695	4067	4847	1173·75
Average	1·125	·058	3·925	782·5	677·83	807·83	195·625

REMARKS.—Each piece broke short.

TABLE XC.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	665	15,680	3,920
8		660	15,120	3,780
9		625	10,640	2,660
10		612	10,304	2,576
11		715	10,800	4,200
Total . .	...	3277	68,544	17,136
Average .	...	655	13,709	3,427

TABLE XCI.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	2·875	11·500	22·500	38·500
16—19	2·375	9·500	24·000	38·125
20—23	2·250	10·625	22·125	37·500
24—27	2·250	10·500	23·125	39·125
Total . .	9·750	42·125	91·750	153·25
Average .	2·437	10·531	22·937	38·312
Do. per in.	2·437	2·633	2·549	2·394

Nos. 28 & 29.

	Inches.			Tons.	Tons.	
One piece,	8·5 × 10 × 12,	crushed with	the weight of	279·2	= 3·285	per sq. in.
,,	8·5 × 10 × 21,	,,	,,	245·5	= 2·887	,,

E = 846100. S = 2054.

THE SANTA MARIA TREE

is found in Honduras, in Central America, but is not considered to be abundant; and very little of it finds its way to the markets of this country. It is of nearly straight growth, and attains the height of 60 to 90 feet, with a circumference of from 7 to 9 feet, yielding very fine logs, measuring from 25 to 50 feet in length and from 12 to 22 inches square.

The wood is of a pale reddish colour, moderately hard, has a clean fine straight grain, and is a little porous. It is generally free from injurious heart or star-shake, has few knots, does not shrink much, and scarcely splits at all in seasoning. It is easily worked, and may there-

fore be considered a very fair substitute for the plainest Honduras or Mexican Mahogany. Some few years since several cargoes of Santa Maria timber were brought to the royal dockyards, and employed there for beams, planking, &c., in ships; and although it would seem never to have been much in favour as a building wood, there is good reason to think that in the absence of Mahogany it might very well be used for cabin fitments, for furniture, and many other purposes.

This wood stands exposure to the weather remarkably well, and is, I think, durable, since a parcel of about 150 loads which I inspected after it had been left in the open in a moist country for about ten years, showed scarcely any signs of deterioration either at the centre or at any other part, and had but few shakes on the external surfaces.

The specific gravity is about the same as Honduras or Mexican Mahogany.

Southwards from Central America there are to be found in the forests of the Brazilian Empire great varieties of timber trees, many of which are no doubt of good quality and fit for architectural purposes, but little or nothing is known of them in this country. I therefore take the present opportunity to place before the reader a brief description of some twenty-four of them, with their uses; observing that specimens of these woods, 3″ × 3″ × 1″ were sent to the Admiralty in 1858, by H.B.M.'s Consul at Rio de Janeiro, with the view to the introduction of some of them for employment in ship-building.

THE ANGELIM-VERMETHO TREE.

The wood is reddish-brown in colour, and moderately heavy. It is probably of crooked growth, as it is used for

ship-timbers in the Brazilian dockyards. Judged by the specimen, this appears to be of good quality.

THE INCARANDA-TAN TREE.

The wood is reddish in colour, close-grained, and fit to be employed for furniture and ornamental work. It is used for these purposes, and might be made available for architectural works, as it appears to be of good quality.

THE SECURIPA TREE.

This is a brown-coloured wood, of moderate weight, and fair quality. It is believed to attain large dimensions, and being of straight growth, it would convert well into planks, boards, and scantlings, for employment in Architecture. It is used for planking and beams in ship-building.

THE GUARABU TREE.

The wood is puce-coloured, and fine in grain; its pores, which are very numerous, being filled with a hard white substance. It is stated to be of straight growth and large dimensions, and would therefore be applicable to naval and civil architecture, as well as other purposes. It is used in ship-building the same as the Securipa.

THE MACARANDUBA TREE.

The wood is red in colour, close-grained, strong, and heavy. It is occasionally used for ship-building in the Brazils; and, if the dimensions are suitable, it probably would be found available for architectural works, as it appears to be of good quality.

THE MERIQUITIARA TREE.

A reddish-coloured wood, moderate in weight, and apparently of good quality. If it attains to large

dimensions it might be employed for architectural purposes. It is used for ornamental work in the Brazils.

THE PAO-DE-PEZO TREE.

A hard, dark, and heavy, close-grained wood, resembling Lignum Vitæ. It may be adapted for blocks and sheaves, and, judging from its appearance, is well suited to those purposes.

THE PEROBA-PARDA TREE.

This is a brown-coloured wood, light, with a fine, straight grain. It attains moderate dimensions, and is used in ship-building.

THE PEROBA-BRANCA, OR P. DE CAMPOS TREE.

The wood is yellow in colour, of moderate weight, close and fine in the grain, and not difficult to work. It takes a high polish. It attains large dimensions, and is fit for employment in architecture, for furniture, and generally in the domestic arts. A sample of this wood, 6″ × 18″ × 10′, measuring 7½ cubic feet, was sent to the Admiralty a short time since, with this description, viz., "Produced in square logs of about 24 inches siding and 60 to 70 feet in length. Sound timber of 30 to 40 inches square is common. The tree is of straight growth, is stronger than Teak, agrees well with iron, and is very durable. The specific gravity is 868. Brazilian iron-clads are built with it."

THE PEROBA-VERMETHO TREE.

The wood is red in colour, and has a smooth, close, fine grain; it is of moderate weight, and resembles, in a slight degree, Pencil Cedar. It was stated with reference to the Peroba-parda, the Peroba-branca, and the Peroba-vermetho trees, that they were "the principal woods

adapted for ship-building purposes, being the largest and the lightest, the weight being about 50 lbs. to the cubic foot. Large sizes of these can be obtained, but only at a great expense. The Peroba-branca is more plentiful than the others, is equally good, and better adapted for spars. It floats about the same as Pitch-pine. Peroba is stronger than Teak, but not so heavy."

THE GRAPIAPUNHA TREE.

This is a yellowish-coloured wood, with a clean, free, straight grain, moderately heavy, strong, and one of the most useful woods for planking or timber. It attains only medium dimensions, but may be turned to account in many ways in the domestic arts, although, judging from the appearance of the specimen, it did not impress me as being of the best quality.

THE TAPINHONHO TREE.

The wood is light brown in colour, porous, with a clean, free, straight grain, moderately heavy, and is used for frame-timbers in ship-building. It attains only moderate dimensions, and is probably of crooked growth.

THE PIQUEA-MARFIM TREE.

The wood is of a bright yellow colour, close and fine in the grain, and would work up well, taking a high polish. It is similar to Satin-wood, but scarcely so hard or so heavy. It is chiefly used for ornamental work, for which it appears to be very suitable.

THE CANELLA-PRETA TREE.

The wood is brown in colour, straight in grain, light, and easy to work. It is of straight growth, and attains considerable dimensions. It is used for decks in ships, and in house-building and carpentry generally; but, when

old, it becomes soft and spongy, and is considered not to be durable.

THE JENIPAPO TREE.

This is a light-coloured porous wood, having a clean, straight grain. It works up well, and is employed in carpentry and the domestic arts; it is also used for planking in ships, but it does not appear to be of a durable character.

THE CAMARA TREE.

This is a light-coloured wood, strong, moderately heavy, of small growth, and is used principally for boats' timbers.

THE PEGUY TREE.

The wood is light brown in colour, straight in grain, porous, moderately heavy and strong. It attains medium dimensions, and is used for planking in ships, and for many purposes in carpentry.

THE ARARIBA-OU-POTUMUJU TREE.

This is a light-coloured wood, with a clean, straight grain. It works up well, and is chiefly employed in the domestic arts. The quality is considered to be inferior.

THE ARARIBA-ROZA TREE.

The wood is red in colour, and has a fine, straight, close grain; it is very light, and is used for furniture and cabin fittings. It attains only moderate dimensions, and is probably a dye wood.

THE CEDRO TREE.

This is a light-coloured and very porous wood, of quick growth, and apparently of inferior quality. It is probably a species of Cedar.

THE MANGALO TREE.

This is a brown-coloured, porous wood, strong, and moderately heavy. It is used for beams in ship-building, in carpentry, and in the domestic arts. Judged by the specimen, the quality appears to be fair, but little is known as to its durability.

THE PAO-SETIM TREE.

The wood is bright yellow in colour, with a clean, fine, straight grain; looks as if it would work up well, and is chiefly used for the manufacture of small wares.

THE JACARANDA-CABIUNA TREE.

This is a dark-coloured, porous, open-grained wood; in appearance it somewhat resembles an inferior quality of Rosewood. It is of moderate weight, and works up well for furniture and for ornamental purposes.

THE VINHATICO TREE.

The wood is yellow in colour, light, open-grained, and is probably of inferior quality. It appears to be a species of Cedar, and is used by the cabinet-maker, and for many purposes in carpentry.

CHAPTER XXVI.

THE TIMBER TREES OF AUSTRALIA.

THE TEWART TREE (*Eucalyptus*).

A VARIETY of the White Gum. Is found principally in the Swan River and King George's Sound district of Western Australia. It is a tree of straight growth and noble dimensions, yielding timber of from 20 to 45 feet in length by from 11 to 28 inches square.

The wood is of a yellowish or straw colour, hard, heavy, tough, strong, and rigid; the texture close, and the grain so twisted and curled as to render it difficult either to cleave or work. It is a very sound wood, possessing few or no defects, with the exception of a mild form of heart and star-shake at the centre, which would necessitate a small amount of waste, if it were required to reduce the logs into thin planks or boards; but, if employed in large scantlings, it will be found a most valuable wood, especially where great strength is needed.

The Tewart shrinks very little in seasoning, and does not split while undergoing that process; it is also characteristic of this wood that it will bear exposure to all the vicissitudes of weather for a long time without being in any but the least degree affected by it. I have known it subjected to this severe test for fully ten years, and when afterwards converted, it opened out with all

the freshness of newly-felled timber. Possibly no better evidence is required to show that this is a durable wood.

It is used in ship-building for beams, keelsons, stern-posts, engine-bearers, and for other works below the line of flotation, for which great strength is required, a weighty material in that position not being objectionable in a ship's construction.

In civil architecture the Tewart is scarcely if at all known in this country, although it might be employed with advantage for many purposes. It would make good piles for piers, and supports in bridges, and be useful in the framing of dock gates, as it withstands the action of water, and is one of the strongest woods known, whether it be tried transversely or otherwise. But it would probably be found too heavy for general use in the domestic arts.

TABLE XCII.—TEWART (AUSTRALIAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·15	4·50	1,071	1147	942	267·75
2	1·25	·00	4·50	972	1173	829	243·00
3	1·15	·20	5·00	1,032	1184	872	258·00
4	1·25	·15	5·00	1,116	1147	973	279·00
5	1·35	·05	4·85	1,017	1170	869	254·25
6	1·35	·10	4·65	966	1194	809	241·50
Total .	7·60	·65	28·50	6,174	7015	5294	1543·50
Average	1·27	·108	4·75	1,029	1169·16	882·33	257·25

REMARKS.—Each piece broke with moderate length of fracture, and very fibrous.

TABLE XCIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	1147	32,580	8,820
8		1184	44,520	11,130
9		1173	46,900	11,725
10		1170	34,160	8,540
11		1147	34,720	8,680
12		1194	51,240	12,810
Total . .	...	7015	244,120	61,705
Average .	...	1169	40,687	10,284

TABLE XCIV.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	4·000	16·875	37·625	67·00
17—20	4·500	16·750	33·125	64·25
21, 22	4·625	16·500		
23, 24	4·750	17·000		
Total . .	17·875	67·125	70·75	131·25
Average .	4·469	16·781	35·375	65·625
Do. per in.	4·469	4·195	3·931	4·102

E = 776990. S = 2701.

THE JARRAH, OR MAHOGANY TREE
(*Eucalyptus marginata*),

is also found in Western Australia, where it is said to be very abundant. It is of straight growth and very large

dimensions, but, unfortunately, is liable to early decay in the centre. The sound trees, however, yield solid and useful timber of from 20 to 40 feet in length by 11 to 24 inches square, while those with faulty centres furnish only indifferent squares of smaller sizes, or pieces unequally sided, called flitches.

The wood is red in colour, hard, heavy, close in texture, slightly wavy in the grain, and with occasionally enough figure to give it value for ornamental purposes; it works up quite smoothly, and takes a good polish. Cabinet-makers may therefore readily employ it for furniture, but for architectural and other works where great strength is required it should be used with caution, as the experiments prove it to be somewhat brittle in character.

Some few years since a small supply of this wood was sent to Woolwich Dockyard, with the view to test its quality and fitness for employment in ship-building, but the sample did not turn out well, owing to the want of proper care in the selection of the wood in the colony. The shipping officer sent only such small squares as might have been produced from logs cut or quartered longitudinally, which left in each case one weak or shaky angle, instead of sending the full-sized compact square log representing all that the growth of the tree would give. It is just possible, however, that this was unavoidable, since it may be inferred from the nature of the conversions that the trees from which they were cut commenced to decay at the centre at or about mid-life, and they had become hollow at the root-end of the stem, long before they arrived at maturity.

This remarkable defect being characteristic of the Jarrah tree, it follows that no compact and solid square log beyond the medium size can be obtained of the full

growth, and hence the conversion of the faulty trees is necessarily restricted to the dimensions of flitches cut clear of the centre.

One peculiarity was noticed in the sample referred to, some of the logs had cavities or blisters, varying from one to several inches in length in the longitudinal direction of the woody layers, and spreading from 1 to 3 inches concentrically, which occurred, like the cup-shake, at various distances from the pith, and at intervals of a few feet along the line of the trunk of the tree. These cavities were partially filled with a hard secretion of resin or gum, which made up in some measure for the solidity, although it did not impart the strength which would compensate for the deficiency of the cohesive properties common to the annual layers.*

From what has been stated respecting the Jarrah timber received at Woolwich, it will be readily supposed that the authorities there did not look upon it with favour, or any desire to employ it for ship-building purposes. It therefore passed to some of the minor services of the yard, and it was while under conversion for these ordinary and inferior works that I took the opportunity of making the experiments which are given in detail in Tables XCV., XCVI., and XCVII.

It is a noticeable fact in connection with the experiments, that all the specimens tried proved deficient in strength and tenacity, by breaking off suddenly with a short fracture, under an average transverse strain of about 686 lbs. weight only, or about 171·5 lbs. to the square inch of sectional area.

Since the foregoing was prepared I have seen some correspondence between the Home and Colonial Govern-

* This peculiar defect is met with in several of the Eucalyptus species, and may occasionally be seen in the Firs and Pines.

ments on the subject of Jarrah timber, and also between the Governor of Western Australia and the leading ship-builders and ship-owners, including Lloyds' surveyor at Freemantle, who had been severally asked to report upon the merits of the Jarrah, with a view to getting it recognised at Lloyds'.

Most of the ship-builders and ship-owners have reported very favourably, and speak of it as a good description of wood. They say that, when used with iron fastenings, neither material is in any way injured by the other, and, also, what is a little remarkable, that it bends well without steaming. In speaking of its merits, however, they nearly all do so under some reserve, such as insisting on the felling being done at a certain time of the year; getting it from some particular district, and so forth. Lloyds' agent at Freemantle, however, does not report quite so favourably of it; indeed, he differs so widely from the rest, that perhaps it would be well to quote his report *in extenso*:—

"In reply to your letter relative to the qualities of the Jarrah of this country as a ship-building timber, I consider it valuable wood for planking purposes as high as the wales, and I also consider it especially excellent wood for small craft which are not intended to be sheathed with metal, inasmuch as it resists the sea-worm better than almost any other wood, and is less liable to foul; but I do not consider it suitable timber for top-sides, or deck work, where it must necessarily be much exposed to the effects of the sun, it being, in such positions, more than ordinarily subject to shrink and warp; and it is rather deficient in tenacity of fibre, so that in situations where eccentric or sudden bends occur it cannot generally be employed with advantage. It is probable you may have heard of the Honourable East

India Company's pilot brig 'Salween,' taking in a cargo of Jarrah at Bunbury. This was supplied by Mr. W. Pearce Clifton, and the vessel was sent at my instance in order to a series of trials of the wood in the Kidderpore dockyard. These trials, I regret to say, were not favourable to the character of the wood, and the result was that no further supply was ordered.

"When last at Calcutta I obtained the sanction of the Government of Bengal to further tests of the wood, the greater portion of the 'Salween's' cargo being then still in store, but I am sorry to say that the result was not more favourable than before."

The clerk of works at Freemantle reporting summarily upon the opinions expressed by the ship-builders and others, says:

"The sound timber resists the attack of the 'teredo navalis' and 'white ant.' On analysis by Professor Abel, it was found to contain a pungent acid that was destructive to life. The principle, however, was not found to be present in the unsound portions. Great care is therefore necessary in preparing the wood for use by flitching the log so as to cut all the defective portions of the heart out, and using only the perfectly sound timber. Fig. 25 will show the mode of flitching, so as to retain the sound wood in any required size for all practical purposes, A B C D E F being flitches. Very much has been said about Jarrah being subject to split when exported to India or England in log. It must be borne in mind that its density renders seasoning very slow, and that the inner portions of the larger trees are in

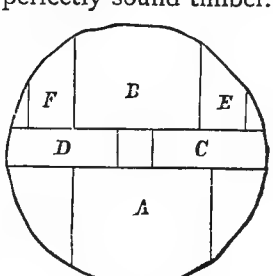

FIG. 25.

a state of decay even while the outer portions are in full vigour. A tree under these conditions, the inner portions comparatively dry, and the outer full of sap, shipped at once to a hot climate like that of India, or to such a variable one as that of England, very naturally bursts from unequal shrinkage, being also exposed to very great changes of temperature. To obviate this peculiarity and apparent defect, let the Jarrah be fallen when the sap is at the lowest ebb, and flitched as previously suggested."*

I have seen it stated in some correspondence from Western Australia that a specimen of Jarrah timber has been chemically examined by Professor Frankland, with the view to ascertain whether there is any peculiar acid or other substance present in it calculated to resist the attacks of the Teredo navalis. It does not appear, however, that anything of the kind has been found which could be credited with the effect referred to. It is believed by the Professor that the singular immunity from attack which this wood enjoys is due either to the odour or taste it possesses. These, though by no means remarkable or repugnant to the human senses, are probably strongly so to the Teredo navalis.†

* The Committee of Lloyds have recently had the subject of Jarrah under their consideration, and determined to class this timber with those in line 3, Table A, of the Society's rules; thus ranking it with Cuba Sabicu, Pencil Cedar, &c., for the construction and classification of ships.

† A late Western Australian almanack says: "None of the neighbouring colonies possess timber of a similar character to the Jarrah, or endowed with equally valuable properties. If cut at the proper season, when the sap has expended itself and the tree is at rest, it will be found the most enduring of all woods. On this condition it defies decay; time, weather, water, the white ant, and the sea-worm have no effect upon it. Specimens have been exhibited of portions of wood which had been nearly thirty years partly under water and partly out. Others had been used as posts, and for the same period buried in sand, where the white ant destroys in a few weeks every other kind of wood. For this peculiar property the Jarrah is

From the foregoing statements it will be seen that there is great diversity of opinion upon the merits of Jarrah timber, and time only will show whether if imported it will find favour with ship-builders and others in this country.

Some three or four years since (about 1871) the Western Australia Timber Company were busily engaged in the forests preparing a large quantity of Jarrah for exportation. The company professes, I believe, to select only the best trees, and to cut them at the proper season; the deliveries should therefore be of the very best sort the country produces. I have earnestly looked for sample cargoes to arrive in the London Docks, but up to the present (1875) none of any importance have been reported.

TABLE XCV.—JARRAH (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·85	·10	4·50	743	987	753	185·75
2	3·25	·15	4·50	638	1049	608	159·50
3	3·25	·15	5·00	661	977	677	165·25
4	3·50	·15	5·00	661	1039	636	165·25
5	3·15	·10	4·50	726	1006	722	181·50
6	3·25	·15	4·75	685	1002	684	171·25
Total .	19·25	·80	28·25	4,114	6060	4080	1028·50
Average	3·21	·133	4·71	685·66	1010	680	171·416

REMARKS.—Each piece broke short.

now much sought after for railway sleepers and telegraph posts in India and the colonies. It is admirably adapted for dock gates, piles, and other purposes, and for keel-pieces, keelsons, and other heavy timber in ship-building. Vessels of considerable burthen are built entirely of this wood, the peculiar properties of which render copper sheathing unnecessary, althoug hthe sea-worm is most abundant in these waters."

TABLE XCVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	987	10,080	2,520
8		1006	13,440	3,360
Total .	...	1993	23,520	5,880
Average	...	996	11,760	2,940

TABLE XCVII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
12·875	13·000	12·625	12·750	12·750	12·750	76·75	12·792	3·198

E = 296810. S = 1800.

THE KARI TREE (*Eucalyptus diversicolor*)

is found in Western Australia, and is said to be very abundant. It is of straight growth, and can be obtained of extraordinary size and length; no reasonable limit to its dimensions being necessary, except that of the

capacity of a ship to carry it. Governor Weld, of Western Australia, says he has estimated trees of this description at 300 feet; and the learned botanist, Baron Van Mueller, of Melbourne, states that the Kari tree reaches the height of 400 feet.

The wood is red in colour, hard, heavy, strong, tough, and slightly wavy or curled in the grain, but it has no figure to recommend it for cabinet purposes. Six logs of this timber, viz., two of 12″ × 12″ × 28′, one of 12″ × 12″ × 34′, two of 24″ × 24″ × 24′, and one of 24″ × 24″ × 32′, were recently shipped at Freemantle by the Western Australian Government for delivery at one of the royal dockyards in England, for experimental trial in the navy, the colonists being of opinion that it will ere long be in great request for ship-building and other architectural works. Unfortunately, however, all these logs had the defect of star-shake, which rendered them unfit for almost any purpose except where they could be employed in very large scantlings.

It was also noticed that the Kari had the peculiar blistery appearance of the annual layers which has been mentioned as common to the Jarrah, consequently this wood is not considered to be suitable for any work requiring nicety of finish, although no doubt it would be admirably suitable for piles for jetties, bridges, &c., and generally for heavy structures where large scantlings and great strength is required. It will not last between wind and earth, though, as far as is yet known, it resists the action of water.

It is much to be regretted that a tree so noble in its dimensions should prove so disappointing in its character; but, like the Jarrah, to which it has some resemblance, it is not, I think, likely to be in request for architectural works in this country.

TABLE XCVIII.—KARI (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·75	·00	5·00	820	957	855	205·00
2	1·25	·00	6·25	725	885	819	181·25
3	1·35	·10	4·60	955	1023	934	238·75
4	·75	·05	7·50	840	987	851	210·00
5	1·00	·05	6·50	920	1013	908	230·00
6	1·00	·05	6·50	915	1023	903	228·75
Total .	6·10	·25	36·35	5175	5888	5270	1293·75
Average	1·01	·04	6·06	862·5	981·33	878·33	215·625

REMARKS.—Each piece broke with scarph-like fracture, 8 to 10 inches in length.

TABLE XCIX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	...	31,080	7,770
8		...	30,800	7,700
9		...	31,360	7,840
10		...	31,360	7,840
11		...	22,120	5,530
12		..	22,960	5,740
Total .	...	...	169,680	42,420
Average	...	981·	28,280	7,070

TABLE C.

Vertical or Crushing Strain on cubes of 6 inches.

No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	
175	195	370	185	5·14

E = 930950. S = 2264.

THE IRON-BARK TREE (*Eucalyptus resinifera*) is found very widely spread over a large part of Australia, and is considered to be abundant. It is a lofty and erect tree of moderate circumference, and yields timber of from 20 to 40 feet in length, by from 11 to 16 or 18 inches square. It is believed to have been named as above by some of the earliest Australian settlers, on account of the extreme hardness of its bark; but it might with equal reason have been called iron-wood.

The wood is of a deep red colour, very hard, heavy, strong, extremely rigid, and rather difficult to work. It has a plain straight grain, and the pores, which are very minute, are filled with a hard, white, brittle secretion. The tree is generally sound, but liable to the defect of both heart and star-shake, and on this account it is not usually very solid about the centre, consequently the timber cannot be employed with advantage except in stout planks or large scantlings.

It is used extensively in ship-building and engineering works in Australia, and in this country it is employed in the mercantile navy for beams, keelsons, and in many ways in the construction of ships, especially below the line of flotation, where a heavy material is not considered objectionable. For civil architecture, the ornamental and the domestic arts, it is not, however, likely to be in much request, its extreme hardness and great weight precluding it from general use.

TABLE CI.—IRON-BARK (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	·85	·0	3·75	1,460	1163	1255	365·0
2	1·00	·0	3·50	1,370	1146	1195	342·5
3	·90	·0	4·00	1,400	1142	1226	350·0
4	1·00	·0	4·00	1,400	1116	1254	350·0
Total .	3·75	·0	15·25	5,630	4567	4930	1407·5
Average	·94	·0	3·812	1,407·5	1142	1232	351·9

REMARKS.—No. 1, wiry fracture, 16 inches in length; No. 2, wiry fracture, 12 inches in length; No. 3, wiry fracture, 10 inches in length; No. 4, broke short to one-third depth, then splintery fracture, 10 inches in length.

TABLE CII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
5	2 × 2 × 30	1142	34,160	8,540
6		1146	26,880	6,720
7		1163	39,480	9,870
Total .	...	3451	100,520	25,130
Average	...	1150	33,507	8,377

TABLE CIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 8.	No. 9.	No. 10.	No. 11.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
18·500	17·625	18·500	19·000	73·625	18·406	4·601

E = 960740. S = 3695.

THE BLUE GUM TREE (*Eucalyptus globulus*)*

is found abundantly spread over a great part of Australia and Van Diemen's Land. It is a tree of straight growth, and attains a height of 200 to 300 feet, with a diameter of from 6 to 25 feet. Like the Jarrah, it is

* In reference to the *Eucalyptus globulus*, the following appeared in the *Homeward Mail* in 1873 :—

"A DISEASE-DESTROYING TREE.—M. Gimbert, who has been long engaged in collecting evidence concerning the Australian tree, *Eucalyptus globulus*, the growth of which is surprisingly rapid, attaining, besides, gigantic dimensions, has addressed an interesting communication to the Academy of Sciences. This plant, it now appears, possesses an extraordinary power of destroying miasmatic influence in fever-stricken districts. It has the singular property of absorbing ten times its weight of water from the soil, and of emitting antiseptic camphorous effluvia. When sown in marshy ground it will dry it up in a very short time. The English were the first to try it at the Cape, and within two or three years they completely changed the climatic condition of the unhealthy parts of the colony. A few years later its plantation was undertaken on a large scale in various parts of Algeria. At Pardock, twenty miles from Algiers, a farm, situated on the banks of the Hamyze, was noted for its extremely pestilential air. In the spring of 1867 about 1,300 of the *Eucalyptus* were planted there. In July of the same year, at the time when the fever season used to set in, not a single case occurred, yet the trees were not more than nine feet high. Since then complete immunity from fever has been maintained. In the neighbourhood of Constantine the farm of Ben Machydlin was equally in bad repute. It was covered with marshes both in winter and summer. In five years the whole ground was dried up by 14,000 of these trees, and farmers and children enjoy excellent health. At the factory of the Gue de Constantine, in three years a plantation of *Eucalyptus* has transformed twelve acres of marshy soil into a magnificent park, whence fever has completely disappeared. In the island of Cuba this and all other paludal diseases are fast disappearing from all the unhealthy districts where this tree has been introduced. A station-house at one of the ends of the railway viaduct in the Department of the Var was so pestilential that the officials could not be kept there longer than a year. Forty of these trees were planted, and it is now as healthy as any other place on the line. We have no information as to whether this beneficent tree will grow in other but hot climates. We hope that experiments will be made to determine this point. It would be a good thing to introduce it on the West Coast of Africa."

characteristic of the larger trees, that, while they appear to be healthy and vigorous, and continue to increase in height and bulk, the centre wastes away near the root, and, when felled, they are often found hollow for some considerable distance up from the butt. The dimensions of the serviceable logs which the tree yields will, therefore, depend very much upon its soundness; but, unquestionably very large scantlings can be procured from it if required.

The wood is of a pale straw colour, hard, heavy, moderately strong, tough, and with the grain twisted or curled. In seasoning deep shakes occur from the surface, and it shrinks and warps considerably.

I remember to have seen in one of the royal dockyards some extremely long and broad planks, or thick-stuff, of this description of timber, which had been apparently flitched from some of the hollow trees before referred to. These, after being kept to season for a while, warped and split to such an excessive degree that it was impossible to use them for any planking purpose whatever. In consequence of this defect it was found necessary to reduce the planks to very short lengths, in order to utilise them at all, and so they passed to quite inferior services.

A specimen log of Blue Gum 31′ × 24″ × 28″ was forwarded with other woods to the London Exhibition of 1862 by the Tasmanian Commissioners; and this, at the close of the Exhibition, was transferred to Woolwich Dockyard for trial experimentally in ship-building. It came in, however, too late, and just when wood was giving place to iron in this branch of architecture, so that no favourable opportunity ever offered for its employment.

This log, although of very large dimensions, had been

cut clear of the centre, and very probably had formed part of one of the hollow trees before alluded to, consequently the tree to which it belonged must have been at the least 6 to 7 feet in diameter.

A plank 6 inches thick was cut from it, which quickly warped or twisted 2 inches, and ultimately went to 3½ inches, and stood at that in 1870. Upon examination then, it was found to be full of deep, fine shakes, but otherwise it was not much changed, and there were no signs whatever of decay, although it had been for a long time exposed to the weather. It seems, therefore, likely to be a durable wood.

In the Australian colonies the Blue Gum is largely employed in ship-building for keels, keelsons, beams, and planking; and in civil architecture for any service where long, straight, and heavy timber is required. It is also largely used upon the farms for fences, &c.

TABLE CIV.—BLUE GUM (AUSTRALIA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 1000.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·15	4·50	767	1079	711	191·75
2	1·75	·20	3·75	602	997	604	150·50
3	1·35	·10	5·75	710	1037	684	177·50
4	1·00	·00	3·75	767	1108	692	191·75
5	1·25	·15	3·50	684	1026	666	171·00
6	1·00	·00	4·00	741	924	801	185·25
Total .	7·60	6·0	25·25	4,271	6171	4158	1067·75
Average	1·26	·10	4·21	712	1029	693	177·96

REMARKS.—Each piece broke with a short fracture.

TABLE CV.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	997	14,560	3,640
8		1079	26,600	6,650
9		1037	24,360	6,090
10		1108	26,600	6,650
11		1026	28,840	7,210
Total .	...	5247	120,960	30,240
Average	...	1049	24,192	6,048

TABLE CVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 12.	No. 13.	No. 14.	No. 15.	No. 16.	No. 17.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
12·875	13·000	12·750	11·125	10·500	13·625	73·875	12·312	3·078

E = 778300. S = 1869.

HE STRINGY-BARK TREE (*Eucalyptus gigantea, E. robusta, or E. obliqua*)

, of straight growth, and takes its name from the strip-ke character of its bark. It is very abundant in Aus-alia and Van Diemen's Land, and flourishes well in ny situation, provided the soil be dry. It attains a eight of from 100 to 230 feet, with a diameter of from to 15 feet.

The wood is of a brown colour, hard, heavy, strong, lose, and straight in the grain. It works up well, and ; employed in the colonies in ship-building, for planking, eams, keels, and keelsons, and in civil architecture for oists, flooring, &c. Upon the farms it is used for fences nd agricultural implements; it is also employed for

The Stringy-bark is liable to the peculiar defect noticed in the Jarrah, and described at p. 191. In a specimen of this wood obtained in 1842 from "Cook's tree" in a forest bordering on Adventure Bay, Van Diemen's Land, there are several imperfect annual layers, which are partially filled with a reddish resinous secretion. It is believed that this specimen was cut from the identical Stringy-bark tree which Captain Cook marked to denote his visit to that place. When I saw it, the tree was partially destroyed, and it is probable that Cook's marks had long before disappeared. It bore on the north side the letters—

LE
GEO GR
a c
GA

and on the south side—

LAN 1802
LAFR=GA
AP:—L
DE . . . .

The Tewart, Jarrah, Kari, Iron-bark, Blue-gum, and Stringy-bark trees, are among the noblest of the vegetable products of Australia and Van Diemen's Land; but there are many others of nearly equal value. During a visit to Auckland, New Zealand, in 1843, in H.M.S. "Tortoise," the Colonial Secretary of Van Diemen's Land informed me by letter that he had sent a box containing samples of forty woods the product of that country; but, unfortunately, it never reached me.

The following table contains a list of these woods, with the particulars of their growth, the soils favourable to them, and the several uses for which they are most suitable; observing that the specimens were collected, and the information respecting them given, by an intelligent sawyer who had been many years employed in the colony.

TABLE CVII.

Description.	Hgt. Ft.	Dia. In.	Where found.	Uses.
White Gum . .	150	25	Hard, dry ground.	Floors, futtocks, treenails.
Brown do. . .	30	24	Do. do.	Ship-building (harder than the other Gums).
Curly do. . .	100	20	Do. do.	Floors, futtocks, ship-building.
Red do. . .	40	18	Low, marshy.	Fencing.
Swamp do. . .	200	30	Do. do.	Shingles, laths, fencing.
White, Stringy Bark . .	...		In all situations.	Roofs, joists, flooring-boards.
Brown Peppermint . .	60	24	Dry.	Flooring-boards, charcoal.
White do. . .	50	24	Dry, hard.	Shingles, laths, fencing.
Scented Myrtle .	15	6	Low, marshy.	Seldom used.
Red do. .	40	12	Swampy.	Same purposes as Pine.
White do. .	20	9	Low, marshy.	House-carpenters' use.
Yellow do. .	20	9	Do. do.	Do. do.
Brown do. .	20	30	Do. do.	Do. and joiners' planes.
Black Wattle .	15	8	Hard, dry.	Bark used for tanning.
Prickly do. .	20	6	Low, marshy.	Seldom used.
Silver do. .	40	12-30	Do. do.	Boat oars; bark for tanning.
He Oak . . .	18	12	Hard, dry.	Firewood.
She Oak, or Beefwood .	18	12	Hard, dry, hilly.	Furniture, firewood.
Boxwood . . .	12	9	Do. do.	Block sheaves, caulking-mallets.
Blackwood . .	15	12	Creek sides.	Naves for wheels, turning.
Lightwood . .	50	24	Low, marshy.	Staves, cabinet-makers'
Dogwood . . .	20	9	Fine, dry.	Not much used. [work.
Pinkwood . .	15	6	Low, marshy.	Turners & cabinet-makers.
Stinkwood . .	20	8	Fine, dry.	Cabinet-makers' work.
Forest Lightwood	15	12	Hard, dry.	Naves for wheels, turning.
Black Willow .	short	6	Sides of creeks.	Basket-makers.
Brown do. .	small	small	Do. do.	Not used.
White do. .	15	8	Hard, dry.	Seldom used.
Honeysuckle .	12	12	Dry.	Floors and knees of small [vessels.
Laurel. . . .	15	9	Low, marshy.	
Pencil Cedar .	50	24	Do. do.	Staves (not much used).
Celery-topped Pine . .	20	20	Do. do.	Doors, sashes, &c.
Sassafras . . .	40	14	Do. do.	Sashes and door-frames.
Cabbage Tree .	15	10	Hard, dry, rocky	Seldom used.
Plum do. .	12	10	Low, marshy.	Gun-stocks.
Emu do. .	small	small	Do. do.	Turners' work.
Cherry do. .	30	9	Hard, dry.	Tool-handles.
Swamp Tea Tree	12	6	Low, marshy.	Useless. [plements.
Tea Tree . . .	30	9	Do. do.	Turners, Agricultural Im-
Musk do. . . .	12	small	Do. do.	Do. do.

CHAPTER XXVII.

MISCELLANEOUS.

THE ALDER TREE (*Alnus glutinosa*)

is a native of this country, and requires a good soil to bring it to perfection. It is generally found near to streams, rivers, and swampy places, where it attains a height of about 50 feet, with a circumference of from 2 to 4 feet.

The wood is reddish-white in colour, soft, and light, with a smooth, fine grain. It works up well, makes good clogs and soles for shoes, and is used in a variety of ways, but is of no great value to the carpenter, except for the making of packing-cases. It has been used for piles, pipes, sluices, &c., and is durable when kept wholly submerged; it is not now, however, much in request for these purposes, as the Elm timber is considered to be far preferable.

The wood of the stem is very plain, and only employed for minor services; but the roots and knots being often richly veined, are used by the turner and cabinet-maker for the manufacture of small wares. The bark is used by dyers and tanners, and charcoal made from the wood is employed in the manufacture of gunpowder.

THE ASH TREE (*Fraxinus*).

Among British timber trees this occupies a very prominent place, on account of its great beauty and highly ornamental character. It attains commonly a height of 30 to 50 feet, with a circumference of from 5 to 6 feet, and grows readily in almost any description of soil, but prefers a rich loam and moisture to bring it to the greatest perfection.

We find it frequently raised in coppices. In the pottery districts, owing to its value as crate wood, it is cut every five or six years, while in other places it is cut down only at intervals of seven or eight years. From the early falls poles for lances are obtained, besides much that is useful to the cooper, the turner, and manufacturer of small wares. The later falls yield timber of more useful dimensions, and this is exceedingly valuable to the coachmaker and the wheelwright.

The wood is greyish-white in colour, of moderate weight and hardness, very even and close in the grain, tough, elastic, and easily worked. To the carpenter, however, it is only found to be available for very minor purposes, as, owing to its great flexibility, it can never be safely used in architectural works. For hoops, and all kinds of agricultural implements, however, it is invaluable, since when steamed or heated it can easily be bent into any form of curve required, without injury to the fibre.

It is peculiar to the Ash that it has no sap-wood—that is to say, there is no perceptible difference between the first-formed and the later or outer layers; there is thus an advantage in the employment of this description of wood over that of most others for any of the purposes for which it is adapted, as it can be utilised to the full diameter of the tree.

Ash is extremely durable if felled in the winter months and properly seasoned before use; but where these precautions are neglected few woods are more perishable. Very great advantage will be found in reducing the Ash logs soon after they are felled into plank or board for seasoning, since, if left for only a short time in the round state, deep shakes open from the surface, which involve a very heavy loss when brought on later for conversion.

Ash wood, when beginning to decay, changes at the centre to a blackish colour, as also it will do if the trees are pollarded or topped off during growth, hence the "best quality" should be uniformly greyish-white throughout.

There are several varieties of the Ash which attain timber size, and those which are raised for ornamental purposes in this country are very numerous. This tree is remarkable for its lateness in putting out its leaves in the spring, and for throwing them off very early in the autumn.

TABLE CVIII.—ASH (ENGLISH).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·75	·05	8·50	879	750	730	219·75
2	1·50	·05	8·75	845	722	702	211·25
Total .	3·25	·10	17·25	1,724	1472	1432	431·00
Average	1·625	·05	8·625	862	736	716	215·5

TABLE CIX.

Tensile Experiments.

Number of the specimen.	Dimensions of the piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
3	2 × 2 × 30	750	15,120	3,780

TABLE CX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 4.	No. 5.	No. 6.	No. 7.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
13·	12·	12·25	12·5	49·75	12·4375	3·1094

E = 573100. S = 2263.

THE CANADIAN ASH TREE (*Fraxinus*)

attains moderate dimensions, and yields the timber of commerce in logs varying from 20 to 40 feet in length, by from 10 to 16 inches square. Oar rafters are also produced from it, and until quite recently considerable quantities were brought to this country. These rafters are pieces roughly shaped to the form of oars, and reduced to a minimum of size, to lessen, as far as possible, the cost of freight.

The wood is reddish-brown in colour, and considerably darker than the English Ash. It is plain and straight in the grain, moderately hard and heavy, tough,

elastic, and easy to work. It is very suitable for employment for oars to boats, and is consequently in great request for that service, while its economical uses are as wide and general as that of our native growth.

TABLE CXI.—ASH (CANADIAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·5	·10	7·00	696	493	847	174
2	3·0	·15	7·75	580	467	745	145
Total .	5·5	·25	14·75	1,276	960	1592	319
Average	2·75	·125	7·375	638	480	796	159·5

TABLE CXII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
3	2 × 2 × 30	558	16,240	4,060
4		544	17,360	4,340
5		625	28,560	7,140
6		625	25,760	6,440
Total . .	...	2352	87,920	21,980
Average .	...	588	21,980	5,495

TABLE CXIII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 7.	No. 8.	No. 9.	No. 10.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
7·25	7·75	12·75	11·50	39·25	9·812	2·453

E = 343980. S = 1675.

THE AMERICAN ASH TREE, OR THE WHITE ASH (*Fraxinus Americana*),

is found chiefly on the banks of the rivers of North America. It is of straight growth, and frequently attains a height of 70 feet, with a circumference of from 3 to 5 feet. It is imported into this country, only sparingly, in logs varying from 10 to 18 inches square, and 18 to 35 feet in length; but comes to us in considerable quantities in a partially manufactured state in the form of machine-made boat-oars, handspikes, &c.

The wood is light brown or whitish in colour, of very moderate hardness and weight, is tough, elastic, clean and straight in the grain, and quite easy to work; it stands well after seasoning, and hence we get from this tree the best material for oars for boats that can be produced. They are much and eagerly sought after by foreign Governments as well as our own, and also by the great private steamship companies and the mercantile marine of this country, consequently there is often a very keen competition for the possession of them.

The best quality wood has a clean, bright, uniform whitish colour, the second is slightly stained with red and yellow shades alternating, while the third, and most objectionable, quality is that in which the red and yellow colours predominate over the healthy shade. Any devia-

tion, therefore, from the bright whitish colour may be taken as indicating a deterioration which will affect its strength and durability.

The United States Ash is much slower in growth than the English, and is probably not so durable.

THE BEECH TREE (*Fagus sylvatica*)

is found in abundance in the central and southern districts of this country. It is also extensively spread over the middle and south of Europe, and varieties of this species are to be met with in America and Australia. It is of erect and straight growth, attains the height of 60 to 70 feet, with a circumference of from 10 to 12 feet, and being of very hardy habits, is often planted in the most exposed positions, to lend beauty and picturesqueness to the surrounding scenery.

The wood is light brown in colour, hard, moderately heavy, close and even in texture, with a fine silky grain. It cleaves easily, works up well, and is remarkable for its minute pores, and for the distinctness with which the medullary rays can be traced.

Beech is employed for chair-making, and it is estimated that at least 12,000 to 15,000 loads are annually required from the English forests for this purpose. Engineers use it for piles and works under water, and it is in great request by turners, tool-makers, and others, who use it extensively in the domestic arts. It makes excellent wedges.

Formerly it was employed in ship-building, and found to answer admirably for the keel and garboard planking; it was also used for the ladders between decks, shot cants, and for many minor services. Upon the Continent, owing to the important property the Beech has of not absorbing water readily, it is much used for making

shoes, and soles for shoes, these being considered far superior to any made of other descriptions of wood. It is also a most valuable article of fuel.

Beech is durable if kept wholly submerged in water or mud; it is also durable if kept quite dry, but if left exposed to the alternations of the weather, it soon becomes doated over with yellowish spots, and rapidly decays.

I had no suitable pieces available for experimental purposes, to try its transverse strength, but the tensile I ascertained by experimenting on three pieces, the average giving 4,853 lbs. per square inch; tried vertically upon four pieces the average was 3·812 tons per square inch. The specific gravity of the seasoned wood varies from 700 to 720, and averages about 705.

THE BIRCH TREE (*Betula alba*, or Common Birch)

is found in nearly every country in Europe. In Bosnia, Turkey, however, I only met with it on the skirts of forests upon the mountains at a considerable elevation.

The European Birch grows naturally a little crooked in the stem, with light, oblique branches, slightly drooping at the extremities, and attains, sometimes, the height of 50 feet, with a diameter of 18 inches, but generally it is of very moderate dimensions. It flourishes on a poor soil in any exposed situation, and is very hardy.

The wood is of a light brown colour, moderately hard, plain and even in the grain, and is easily worked; but it is neither strong nor durable, and is therefore unfit for building purposes. Its chief uses are for cabinet work, chair-making, turnery, and light wares generally. The bark is smooth, thin, white in colour, and is used in tanning. Birch timber is imported in a round state and with the bark on from the North of Europe to our

northern ports, and passes into the manufacturing districts for use in a variety of ways. Very little, however, comes to the London market.

There are several varieties of the Birch tree in America, and among the best are the following :—

Betula rubra, or Red Birch, is found on the borders of rivers in the southern provinces of the United States, and according to Michaux, it delights as much in heat as many other species do in cold. It attains the height of 70 feet, with a diameter of 30 to 36 inches. Its uses are chiefly for cabinet work and turnery.

Betula lenta, or *B. nigra*, the Black or Cherry Birch of North America, is, perhaps, the most valuable, and is abundant in the midland states. It differs, however, from the common Birch of Europe, and flourishes best in a rich soil. It is of straight growth, and, in favourable situations, attains the height of 75 feet, with a diameter of 30 to 36 inches.

The wood is of a yellowish colour, moderately hard, straight and even in the grain, close in texture, easy to work, and on account of its superior quality to the other species, it is sometimes in America called Mountain Mahogany. American Birch is imported into this country in logs varying from 6 to 20 feet in length, by 12 to 30 inches, pretty well squared, and having only 1 to 2 inches wane upon the angles. The sap is 2 to 4 inches thick.

The heart-shake is small, and the wood near the pith is, for the most part, solid; very little loss can, therefore, arise from its conversion. It is used extensively for furniture, turnery, and in a variety of ways in the domestic arts.

Dark, damp-looking spots and rings are often seen on the ends of the logs, which seem to indicate incipient

and early decay. I imagine, therefore, that it is unsuitable for building purposes.

The specific gravity of European Birch is about 700, and that of American about 600 to 640.

THE BOX TREE (*Buxus sempervirens*)

is found nearly all over the South of Europe, from Spain to the Sea of Marmora; but in this country only sparingly on warm, chalky hill-sides. It is also found in the West Indies.

The Box tree seldom attains timber dimensions, and is not a building wood; it is, however, invaluable to the mathematical instrument maker, the turner, and the wood engraver, on account of the closeness of its grain and evenness of texture; and in the manufacturing districts it is in great request for bosses and boxes in connection with their machinery.

Boxwood of excellent quality is imported from Abasia, in Circassia, and also from Turkey. It is brought in round logs or billets, 3 to 8 feet in length, by 3 to 12 inches in diameter, with the bark on, which is thin, smooth, and of a grey colour. It has no sap-wood.

The wood is yellow in colour, hard, heavy, free from heart-shake, and about the most solid at the pith that can be met with. It works up smoothly and with a silky lustre.

Boxwood is liable to split somewhat spirally from the outside of the log, but stands well after being worked, when thoroughly seasoned; and as it is seldom required for use except in small dimensions, no great loss is ever sustained in its conversion.

Boxwood is sold by weight, and in the London and Liverpool markets realises from £4 to £15 per ton, according to quality and dimensions.

The specific gravity of Box varies from 950 to 980.

THE CHESTNUT TREE (*Castanea vesca*).

The sweet Chestnut attains to large dimensions, and is found thinly scattered over most of our English counties. It is abundant in the southern parts of Europe, and extends eastward to the Caucasus. It is also met with in the mountainous parts of Virginia, Georgia, and Carolina, in North America.

The wood is brown in colour, of moderate hardness and weight, has a clean fine grain, and is rather porous. The medullary rays cannot be distinctly traced in it, and it has no alburnum or sap-wood. These two characteristic points serve to distinguish it from the British Oak, for which it has sometimes been mistaken. There is also this further difference between them, the Chestnut is of slower growth than the British Oak.

The Chestnut timber stood in high favour at one time, and it is even supposed that preference was given to it over Oak for employment in some of our oldest and best specimens of civil architecture, but upon careful examination of the woods during reparations it has generally proved to be Oak of native growth that had been used, and not Chestnut.

The Chestnut is scarcely ever used now except for very common or ordinary works, such as posts, rails, palings, hop-poles, &c.; but as it is durable when kept wholly submerged, it may be used for piles, sluices, &c., with advantage.

It is on record that specimens of the sweet Chestnut have attained to a very great size and remarkable longevity; one standing lately in Sicily is said to have measured 160 feet in circumference; the centre part, however, was quite gone, and the cavity thus formed was considered to be sufficiently large to give shelter to a

troop of at least eighty men. Another, but much smaller, in the department of the Cher, France, measured over 30 feet in circumference; this has been known for five or six centuries as the great Chestnut tree, and must be of very great age.

THE ENGLISH ELM TREE (*Ulmus campestris*)

is found growing in the hedgerows of most of the counties, and forming the avenues in many of the parks of England. It also occupies a wide range over Europe, preferring generally low lying, level ground, with a moderate degree of moisture. It thrives well in every variety of soil, provided the situation be open, but attains the greatest perfection when grown in a rich loam, reaching, under favourable circumstances, the height of 60 to 70 feet, with a circumference of from 7 to 8 feet.

The wood is brown in colour, of moderate weight, hard, tough, porous, and much twisted in grain, which makes it difficult to work when thoroughly seasoned, and also next to impossible to split it. The medullary rays, if present in this species of wood, are not distinguishable, and this in some measure accounts for its strong cohesive properties.

The economical uses of the Elm are very great, since we find it extensively employed in engineering works for piles, pipes, pumps, blocks, &c.; it is also used for keels and planks under water in ships. Carpenters, wheelwrights, turners, and cabinet-makers also use it for so many purposes, that it would be very difficult to enumerate them.

Elm timber, if used either where it is constantly under water, or in any situation where it is kept perfectly dry, excels almost every other kind of wood in durability. But under any other circumstances it decays rather

rapidly; therefore, the surveyor, in selecting this wood, should, if he requires it for any purpose where durability is an object, decline to take any but fresh-cut logs, since, if they have been left for more than about ten to twelve months exposed to the weather, they will be liable to prove doated, and very possibly may have changed from the natural brown to a yellowish colour, which is a sure sign of a deterioration in the quality. The bark of Elm usually falls off in about ten to sixteen or eighteen months after the tree is cut down, the surface after this gets blanched by exposure, and there are few logs that have been felled so long that are quite free from incipient decay.

There is almost no heart, cup, or star-shake in the common English Elm, but the defects are often nevertheless of a very serious character, and are chiefly occasioned by the rough treatment it is subjected to in the way of pruning—the knots or root end of the branches being left exposed, decay and wet-rot frequently soon follow, then hollow places are formed in the centre, and the tree is ruined. Birds frequently build in these cavities, and on several occasions in the course of my experience in working this wood, perfect nests, with fresh-looking eggs, have been found deeply buried in the log.

The sap of Elm timber is generally from 1½ to 3 inches thick, but it forms an exception to the rule which forbids the employment of sap-wood in architecture, as all parts of it have been proved to be equally durable. The waste, therefore, to be incurred in the conversion of the log is very small, provided always that the planks and boards are only cut as they are required. This precaution is considered necessary, owing to the great liability of the planks to warp or twist, which would soon render them unfit for use.

As Elm timber is best and most durable when worked up soon after the tree is felled, it is not necessary to keep in store more than is required from year to year. If, however, it should be thought desirable to accumulate stock with the view to provide against emergencies, it will be most effectually preserved for future use by keeping it constantly under water, or burying it in mud.

Table CXIV., showing the transverse strength of this wood, is not so full or satisfactory as could be desired, owing to the difficulty experienced in finding pieces sufficiently straight in the grain for experimental purposes. The Tables CXV. and CXVI., showing the tensile and vertical strength, are, however, more reliable.

TABLE CXIV.—ELM (ENGLISH).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 700.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inches.	Inches.	lbs.			lbs.
1	...	...	3·50	...	578	...	...
2	5·25	1·25	7·50	510	571	625	127·5
3	...	...	6·25	...	558	...	...
4	...	...	4·00	...	553	...	...
5	4·75	1·30	5·50	350	545	450	87·5
6	4·70	1·35	5·00	320	542	413	80·0
Total .	14·70	3·90	31·75	1,180	3347	1488	295·00
Average	4·90	1·30	5·291	393	558	496	98·33

TABLE CXV.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	690	21,060	5,040
8		625	26,880	6,720
9		611	18,480	4,620
Total . .	...	1926	66,420	16,380
Average .	...	642	22,140	5,460

TABLE CXVI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	No. 15.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·125	10·00	10·75	10·50	10·25	10·375	62·00	10·333	2·583

E = 250820. S = 1032.

Contracts are annually made for the supply of English Elm timber for the royal navy, according to the following specification and conditions, the quantities of the several classes, and the quantity required for each of the dockyards, of course varying from year to year, to suit the works in hand.

SPECIFICATION.

ENGLISH ELM TIMBER.

Contents of each log.	Loads.	Price per load.
Feet. Feet.		£ s. d.
190 to 300		
189 ,, 160		
159 ,, 130		
129 ,, 100		
99 ,, 70		
99 ,, 60 (Wych) . .		
Under 60 ,, . .		
75 to 250 (for Blocks)		
Total		
Of which are to be fit for keel-pieces . .		

A premium price is paid for timber suitable for keel-pieces; logs qualified for this purpose are not to exceed 250 feet cube.

The conditions of the contract are—

1. That all the timber shall be felled in the winter; that is, within the 1st November and the end of February.

2. The timber will not be required to be delivered of an octagonal form, but must be so hewn or squared as that at each of the measuring places no surface or square shall be less than one-fourth of the diameter of the piece where the measurement is to be taken (Fig. 26*b*); and in measuring at the yards, the contents of the butt-lengths will not be taken separately, but the lengths for measurement will be regulated by the several stops or joggles.

3. The common Elm timber to be fairly grown and free from sudden bends (Fig. 26*a*); to be 24 feet in length and upwards, meeting at 28 feet; and each piece of timber to be measured for contents by calliper measurement, as far as the spire (which is not to be cut off from any tree) will hold 15 inches in diameter; and no top will be received except the spire. No tops will be received at the yards detached from the log.

4. The Elm timber for keel-pieces to be straight, fairly grown, and to square 17 inches and upwards. The shortest length is to be 28 feet.

FIG. 26*a*.

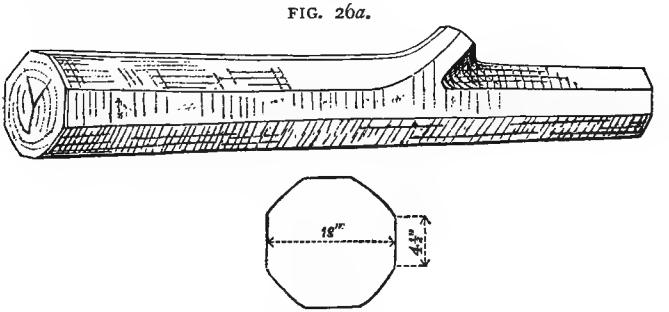

FIG. 26*b*.

5. The Elm timber for blocks to be clean butt-lengths, free from knots; to be 16 feet in length and upwards, meeting at 20 feet. The calliper measure of the mid-length to be not less than 26 or more than 36 inches.

6. The Wych Elm timber to be 16 feet in length and upwards, meeting at 20 feet; each piece of timber to be measured for contents by calliper measurement as far as the spire (which is not to be cut off from any tree) will hold 8 inches in diameter; no top will be received except the spire. No tops will be received at the yards detached from the log; all the timber to be of fair growth,

free from sudden bends and knots, and suitable for conversion into plank and board.

7. All the timber to have the bark on the wanes, to be good, sound, merchantable, well conditioned, such as shall be approved of by the officers of the respective yards, and in every respect fit for the service of her Majesty's navy.

THE WYCH ELM TREE (*Ulmus montana*)

is most abundant in the North of England and in Scotland, and is only sparingly scattered over the southern counties.

Ordinarily this description of Elm is of very moderate dimensions, although instances are by no means rare of its attaining a great size. In Evelyn's "Sylvia," we are informed that a Wych Elm, which grew in the park of Sir Walter Bagot, in Staffordshire, measured 17 feet in diameter at the base, and was estimated to contain the large quantity of 97 tons of timber.

The Wych is readily distinguished from the common Elm by its smoother and thinner bark, by the absence of heavy branches low down on the stem, and by the larger size of the leaves.

The wood is of a light-brownish colour, rather more porous than the common Elm, tough, and moderately hard when seasoned. Being generally clean and straight in the grain, and very flexible when steamed, it is in great request for boat-building; in other respects its uses are as varied and numerous as those of the common Elm.

THE DUTCH ELM TREE

closely resembles the Wych Elm, and is found growing in this country under the same conditions of soil, aspect, &c.

The wood is somewhat darker in colour than the Wych, is tough, hard, and of the same porous and flexible character, but being more frequently subject to star-shake, it is considered to be an inferior variety, and is consequently less sought after. It is not generally so suitable for boat-board as the Wych Elm, but for any ordinary purpose it might be used as a substitute for either of the other kinds. In commerce it is known as the Dutch or Sand Elm.

The English Elm trees are remarkable as being among the first in leaf in the spring, and the latest in shedding them in the autumn.

THE CANADA ROCK ELM TREE (*Ulmus Americana*) is found growing abundantly in the low woods of North America, from New England to the Carolinas. It attains moderate dimensions, with a clean straight stem, and few heavy branches, and yields timber for the market in logs of from 20 to 40 feet in length and from 11 to 16 inches square.

The wood is whitish-brown in colour, hard, tough, and flexible, with a fine, smooth, close, silky grain; and as it has only a small quantity of sap-wood it can be worked up closely and economically. It is necessary, however, to remove the sap in the conversion of the log, as, unlike that of the English Elm, it is of a perishable character.

Rock Elm is often substituted for the English common Elm for garboards and planking in ship-building, as it is very durable when employed under water; it is also used for ladder steps, gratings, &c., on account of its clean whitish appearance; and owing to its flexible character it is frequently used in boat-building. It cannot, however, be used with advantage in bulk, or

even in plank, if exposed to a dry current of air, as under such circumstances it is very liable to split with fine deep shakes from the surface.

Having this serious liability to rend in seasoning, the logs should never be left a week exposed to the influence of drying winds without some kind of protection, for even less than that time is often sufficient to bring about an amount of deterioration which will greatly affect their value. Therefore, to preserve this timber for future use, it should be treated in the same manner as the English common Elm, namely, by immersing it in water; or, if this cannot be done conveniently, it should be cut into planks of thicknesses which would be available for further conversion if required, taking care to store it in a dry, cool place, under cover, but quite free from draught.

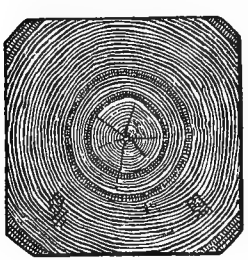

FIG. 27.

The star-shake, in a mild form, is rather common to this description of timber, but does not usually extend to more than 2 or 3 inches from the pith; there is also another, and rather peculiar defect, consisting of several complete consecutive circles of the annual layers being softer and more spongy than the natural or healthy wood (Fig. 27). They are darker in colour, and contain much moisture, and are, as pointed out in Chapter VI., p. 34, considered detrimental to the quality, strength, and durability, and consequently, to the value of the tree. The surveyor should, therefore, in selecting this wood take only the logs with a uniform whitish colour for his best work, and leave those which are marked with the dark annular layers upon the ends for inferior purposes.

In all other respects the Canada Rock Elm is a safe

wood for the converter to deal with, the instances of defects being found in opening it, arising either from pruning or from accidental causes, being extremely rare.

About 2,500 to 3,000 loads of this wood are imported annually into each of the London and Liverpool markets, to meet the wants of private dealers, who employ it for coach-making, turnery, boat-building, &c. The Government also take about 600 to 700 loads annually for the use of the royal dockyards, stipulating in their contracts that it shall be of the first quality, from 11 to 15 inches square, averaging 12½ inches; 20 feet and upwards in length, averaging at least 24 feet in length, and to be well squared, and free from knots.

The Canada Rock Elm is a remarkably slow-growing tree, the slowest in fact with which we have to deal; it makes only one inch of wood diameter in about fourteen years.*

TABLE CXVII.—ROCK ELM (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 700.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·60	·25	8·55	935	760	861	233·75
2	1·85	·30	8·75	946	753	893	236·50
3	1·75	·30	9·00	899	735	856	224·75
4	1·90	·35	8·65	918	740	868	229·50
5	1·85	·25	8·75	927	738	879	231·75
6	1·55	·30	9·05	895	765	819	223·75
Total .	10·50	1·75	52·75	5,520	4491	5176	1380·00
Average	1·75	·29	8·79	920	748	863	230·00

REMARKS.—All fractured and crippled, but not completely broken asunder.

* See Tabular Statement in Chapter II., on the comparative rate of growth of trees, p. 18.

TABLE CXVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	740	32,480	8,120
8		738	31,920	7,980
9		765	42,000	10,500
10		753	38,640	9,660
11		735	33,040	8,260
12		760	42,280	10,570
Total . .	...	4491	220,360	55,090
Average .	...	748	36,727	9,182

TABLE CXIX.

Vertical or Crushing Strain on cubes of—

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	3·000	15·75	37·125	62·5
17—20	3·125	16·25	36·625	61·0
21, 22	3·500	17·00	—	—
23, 24	3·625	16·00	—	—
Total . .	13·250	65·00	73·75	123·5
Average .	3·312	16·25	36·875	61·75
Do. per in.	3·312	4·062	4·097	3·859

E = 618550. S = 2415.

THE HORNBEAM TREE (*Carpinus betula*)

is an indigenous British tree, which thrives well even upon a poor soil, and attains the height of 40 to 50 feet with a circumference of from 30 to 45 inches.

The wood is white in colour, close in the grain, hard, tough, strong, and of moderate weight; its pores are minute, the medullary rays are plainly marked, and there is no sap or alburnum; it may, therefore, be worked up to great advantage. Hence we find it employed for a variety of purposes; it is useful in husbandry, and agricultural implements made of the sound and healthy wood wear well, as it stands exposure without being much affected by it. It is also used by engineers for cogs in machinery, a purpose for which it is well suited.

The Hornbeam tree, if pollarded, becomes blackish in colour at the centre, owing to the admission of external moisture. This renders it unfit for many purposes where a clean, bright surface is required, and generally it proves detrimental to the quality and durability of the timber.

This wood when subjected to vertical pressure cannot be completely destroyed, its fibres, instead of breaking off short, double up like threads, a conclusive proof of its flexibility and fitness for service in machinery.

I was not able to secure suitable specimens of the standard dimensions to test the transverse strength of this wood, and consequently only the tensile and crushing or vertical strains appear in the tables.

TABLE CXX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
1	2 × 2 × 30	808	28,560	7,140
2		815	27,440	6,860
3		815	23,520	5,880
4		836	22,960	5,740
Total . .	...	3274	102,480	25,260
Average .	...	819	25,620	6,405

TABLE CXXI.

Vertical or Crushing Strain on cubes of 2 inches.

No. 5.	No. 6.	No. 7.	No. 8.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
14·25	15·	15·125	15·	59·375	14·844	3·711

CHAPTER XXVIII.

FIRS.

THE DANTZIC FIR TREE (*Pinus sylvestris*).

THE wood of this tree takes its name from the port of shipment, the forests from which it is drawn being spread over very large districts in Prussia proper, Prussian Poland, and upon the borders of Russia, whence the timber, after being prepared partly in the round and partly in the square state, is floated in large rafts down the River Vistula to Dantzic, advantage being taken of this mode of transit for bringing considerable quantities of corn from the interior to be shipped to foreign markets.

These trees frequently grow to a great height, and throw out numerous branches; they yield the Dantzic Fir of commerce in the shape of rough spars for masts, from small to medium sizes; timber, varying from 11 to 20 inches square and from 18 to 45 feet, and occasionally even greater lengths; deals of various thicknesses, from 2 to 5 inches and 18 to 50 feet in length; railway sleepers, &c., &c., which are shipped in large quantities chiefly to this country.

The Dantzic Fir is known locally as Redwood, although its colour is whitish, and only slightly tinged with red. It is even and straight in the grain, tough, elastic, and easily worked, and as it is moderately hard in texture, as well as of light weight (the specific gravity being only about 582), it is used more generally, and in much larger quantities, than any other kind of Fir for building purposes. It is characteristic of it to have a large amount of alburnum or sap-wood, especially upon

the small and medium size trees. Very great care therefore necessary in the conversion of this wood, ensure the production of the deals and other scantli of the required dimensions free from sap, the difficu being often enhanced by the fact that in working on fr logs, the sap can scarcely be distinguished from the he wood, although, if exposed a short time only to atmosphere, the difference soon becomes visible, moisture of the latter drying up more rapidly, and leav it lighter in colour. The Dantzic converter is, howe by dint of practice, generally so correct in his judgm that he seldom fails to obtain all that he requires, e from logs which have a very unpromising appearance.

Previous to shipment at Dantzic, the whole of timber in the rafts is carefully sorted over, and the b of the round wood, *i.e.*, the longest, straightest, and fir pieces, and those most free from knots, are selected exportation, under the name of "hand masts," very li being required to be done to them beyond topping th off to the established length, which is proportioned their diameter. A few trees, perhaps, which are perfectly fair and straight in their growth, being trimn or dressed as may be necessary to make them appear

"Hand mast" is a technical term applied by mast-maker to a round spar, holding at the least 24, not exceeding 72, inches in circumference. They measured by the hand of 4 inches, there being als fixed proportion between the number of hands in length of the mast and those contained in the circ ference, taken at one-third of the length from butt-end. All the round pieces which measure less t 24 inches in circumference at the base are simply ca spars or poles, while those which measure more than inches in circumference are generally dressed to

octagonal or square form, and are then called "inch-masts." These inch-masts, hand-masts, and spars or poles, if straight, and free from large knots and excess of sap, are much esteemed by the mast-makers, and are considered equal, if not superior, to those obtained from Riga.

The first selection from the round wood having been made for the mast-pieces, the remainder undergoes a further sorting over, to secure the logs most suitable for conversion into deals, and these are always in great request in England, France, Prussia, &c., the respective governments requiring them in large quantities for the decks of their ships of war. There is also the ordinary demands of the private trade, which are sometimes very considerable. To be fit for deck purposes the deals must be of the very best quality, and free from large or defective knots, cup-shake upon the upper or outer surface, and they must also be free from sap.

The round wood logs remaining from these two sortings serve for conversion into plank and board for the home or country trade, and, as in this they are not very particular about the sap-wood being removed, it is all worked up very closely, and with the least possible loss. The coarse and irregularly grown trees, which are brought into Dantzic in a round state, are a special class, and require but little consideration; they pass at once for conversion into railway sleepers, and are exported in large quantities to various parts of the world.

The square timber also undergoes a very careful sorting with the view to its classification under the heads of crown, best, good, and common middling qualities, and sometimes even making a fifth class, if it be short, small, or irregular.* The prices of these several descriptions

* There is also a small or undersized class of Memel and Dantzic Fir timber, called Mauerlatten.

vary with the quality and average length; and, at the present time (1875) in the London market, they stand at about seventy to ninety shillings per load for best, sixty to eighty shillings per load for good, and fifty-two to fifty-eight shillings per load for common middling. The crown and the fifth class being special distinctions, are, respectively, a little above and a little below these prices.

There are no reliable or recognised official brands by which the several qualities of Dantzic Fir timber may be known, there being no sworn Bracker to make the sorting; consequently, as each merchant acts for himself, he can give to it any particular distinguishing mark he pleases, and of course this will be only known in his own private circle, or, at most, to the trade of the district. The result is, there are often as many marks for each quality as there are merchants dealing in the article, thus making it necessary to see the several kinds in order to determine which would be most suitable for the work to be done. The practice is not a very satisfactory one, since it is not an uncommon thing to find the best middling timber of one merchant 3 to 4 or 5 per cent. better in quality than that of another, and the same with regard to each of the other classes brought into the market.

Dantzic Fir is employed more extensively in civil architecture than, perhaps, any other description of wood for joists, rafters, trusses, floors, scaffolding, &c.; it also enters largely into the construction of bridges and railway works; indeed, it is not too much to say that few works in this country are ever carried on without its capabilities being in some way turned to account. In ship-building it is employed for beams to carry the upper and lighter decks, occasionally for bottom plank-

ings, and also for various fitments in cabins and store-rooms; and its special fitness for deck purposes has been already mentioned. Further, the cheap, common, middling quality is in request for props, or shores, required for supporting a vessel while in course of construction, or while in dock undergoing repairs, for which, and similar purposes, its coarse character is not an objection.

Having in former chapters, treating of the hard-wood trees, adopted the British Oak timber as the standard of quality and fitness for all the purposes of naval and civil architecture, so I propose to adopt the Dantzic Fir timber—the most important and generally useful of the Firs and Pines—as the standard of comparison for the soft or white wood class. I have, therefore, gone more fully into the experiments on this timber than it would have been possible for me to do with each of the other descriptions.

The transverse experiments recorded in Table CXXII. were made upon pieces of well-seasoned wood, of good average quality, and in every respect fit to be employed in the best architectural works, their specific gravity ranging from 478 to 673, and averaging 582. Of these specimens the elasticity of one piece was perfect immediately after the weight of 390 lbs. was removed, and in each of the others it was very nearly so, the average of the whole giving only ·066 of deflection. All these would probably have recovered their straightness if time had permitted of their being left for only a short period prior to proceeding with the breaking strain.

The strains required to break these specimens varied very much, the minimum being 175 and the maximum 242·5 lbs., the average 219·16 lbs. on the square inch. The deflections at the crisis of breaking varied from 4·5 to 6·15 inches, and averaged 5·142 inches.

The experiments for determining the direct cohesive strength are, as before stated, somewhat difficult to carry out, even upon the hard woods, but they are infinitely more so on the soft woods, owing to the liability of the pieces to crush in the clamps holding them before the true tensile strain could be reached. The results given in Table CXXIII. were, therefore, only obtained after much perseverance and not a few failures. The five pieces subjected to the strain bore respectively 2,240, 2,800, 3,220, 3,416, and 4,480 lbs., giving an average of 3,231 lbs. as the direct cohesion per square inch. Their specific gravities varied from 512 to 639, the average being 603, which is very near the average specific gravity of the pieces tried for the transverse strength.*

A great many experiments were made to ascertain the resistance of this wood to a vertical or crushing force, the details of which are given in Tables CXXIV. to CXXVIII. From Table CXXV. it may be deduced that the proportion of length to section best adapted for carrying the greatest weights is when the sectional area in inches is to the length in inches as 4:5 or $\sqrt{\frac{4}{5}}\,L$ = side of square for the base. This confirms the opinion before given as regards English Oak; but the rule must rather be considered approximate than absolute, for in the experiments on pieces 3″ × 3″ (Table CXXVI.), the maximum strength lay in that of 12 inches in length, making the proportion as 9:12 ($\sqrt{\frac{9}{12}}\,L$ = sectional area). If, however, the area of the base (or the sectional area) be too small for the length of the pillar, it will be liable

* The results of nearly all my experiments on the tensile strength of woods are lower than the values given by Rankine, Tredgold, and some others. But as the specimens 2″ × 2″ × 30″ were each tested by hydraulic machinery most carefully applied, the tabular values here given may, I consider, be depended upon.

to bend or buckle up under the load, showing that stiffness is an important element in the condition of strength.

Specimens were also tested measuring 4″ × 4″ (Table CXXVII.), but the results obtained were scarcely so satisfactory as before, in consequence of the sudden falling off in strength in the 21-inch piece; still there is, perhaps, sufficient to indicate that the maximum of strength would be in a length of about 20″, in which case the proportion of base to length would still be as 16 : 20 or 4 : 5.

Table CXXVIII. shows the result of some vertical tests on pieces 6″ × 6″ and even larger, but the lengths are not in the same proportion to the scantlings given in former tables, there not being any means at my disposal for holding pieces of greater length than 30 inches. Whether the result would have been the same if this had been possible, cannot therefore be determined by the experiments herein referred to.

TABLE CXXII.—FIR (DANTZIC).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·25	·10	5·15	845	534	949	211·25
2	2·00	·05	4·50	700	478	878	175·00
3	1·25	·00	4·65	970	673	866	242·50
4	1·25	·05	5·25	856	512	1003	214·00
5	1·75	·10	6·15	944	639	886	236·00
6	1·25	·10	5·15	945	656	864	236·25
Total .	9·75	·40	30·85	5,260	3492	5446	1315·00
Average	1·625	·066	5·142	876·66	582	908	219·16

[*] Nos. 1, 2, and 3 broke with a scarph-like fracture, 10 inches in length; 4 and 5 a little longer and more splintery: 6 about 15 inches, and also splintery.

TABLE CXXIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	534	13,664	3,416
8		673	17,920	4,480
9		639	12,880	3,220
10		656	11,200	2,800
11		512	8,960	2,240
Total . .	...	3014	64,624	16,156
Average .	...	603	12,925	3,231

TABLE CXXIV.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
12—15	3·625	12·875	27·875	47·875
16, 17	2·625	12·750	—	—
18, 19	3·750	12·500	—	—
20, 21	3·250	13·000	—	—
22, 23	3·250	12·125	—	—
24, 25	2·375	12·875	—	—
Total . .	18·875	76·125	—	—
Average .	3·146	12·687	27·875	47·875
Do. per in.	3·146	3·172	3·097	2·992

TABLE CXXV.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
26	1	2×2	4	0 2	756	10·875	2·719
27	2			0 3½	756	12·687	3·172
28	3			0 5	720	11·875	2·969
29	4			0 7	756	13·750	3·437
30	5			0 7¾	669	13·750	3·437
31	6			0 9	648	13·000	3·250
32	7			0 10	617	12·750	3·187
33	8			0 11½	621	12·125	3·031
34	9			0 15	720	12·125	3·031
35	10			0 15½	669	12·500	3·125
36	11			1 2½	726	11·625	2·906
37	12			1 5½	774	12·000	3·000
38	18			1 10½	636	11·500	2·875
39	24			2 6	684	10·875	2·719
40	30			2 14	662	10·500	2·625

TABLE CXXVI.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
41	8	3×3	9	1 15	744	21·750	2·417
42	9			1 15½	672	21·500	2·388
43	10			2 1	634	21·625	2·403
44	11			2 4	629	21·500	2·388
45	12			2 15	752	21·875	2·431
46	13			2 13½	672	15·250	1·694
47	14			3 4	713	20·250	2·250
48	15			3 5	679	21·250	2·361

TABLE CXXVII.

Vertical Experiments.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
49	15	4×4	16	5 0	576	37·500	2·343
50	15			4 5	497	32·000	2·000
51	16			5 9	600	36·250	2·265
52	16			4 10	500	34·500	2·156
53	17			6 4	635	36·500	2·278
54	17			4 14	496	32·250	2·015
55	18			5 4½	507	37·875	2·368
56	18			5 9½	556	33·500	2·093
57	19			5 7	494	33·875	2·118
58	20			5 14	508	34·500	2·156
59	21			6 2	504	28·000	1·750
60	22			6 6	501	33·900	2·118
61	23			6 10	498	37·700	2·356
62	24			6 11	495	34 400	2·150

TABLE CXXVIII.

Vertical Experiments on pieces of various dimensions.

Number of the specimen.	Length in inches.	Size in inches.	Square inches in base.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on the square inch.
				lbs. ozs.		Tons.	Tons.
63	12	6×6	36	8 15	571	132·00	3·640
64	18			15 4	654	153·00	4·277
65	24			17 4½	554	153·00	4·277
66	30			24 4	622	122·20	3·394
67	12	9″ × 10″	102·37	27 0	608	245·40	2·397
68	15			33 13	608	279·20	2·727
69	15	10″ × 10″	110·25	38 12	648	214·80	1·953
70	18			48 6	673	183·80	1·671
71	18	10′ × 10″	107·5	39 8	564	254·40	2·292
72	21			45 13	561	279·20	2·600

E = 579190. S = 2301.

Contracts for the supply of Dantzic Fir timber, Fir deck deals, and Oak plank for the royal navy, are made annually, the quantities of each kind varying according to the requirements of the several dockyards.

The following is the specification and conditions under which they are obtained :—

DANTZIC FIR TIMBER.		Loads. £ s. d.
Best Middling . . .	At per load . .	
Good ,, ...	Do. . . .	
Common ,, ...	Do. . . .	
Deck Deals.		
4 Inches { Crown	At per 40-ft. run of 3 in.	
4 Inches { Crown Brack	Do. . . .	
3½ ,, { Crown	Do. . . .	
3½ ,, { Crown Brack	Do. . . .	
3 ,, { Crown	Do. . . .	
3 ,, { Crown Brack	Do. . . .	
2½ ,, { Crown	Do. . . .	
2½ ,, { Crown Brack	Do. . . .	
2 ,, { Crown	Do. . . .	
2 ,, { Crown Brack	Do. . . .	
Stage Deals.		
2 ,, ...	Do. . . .	

DANTZIC OAK PLANKS.		Loads. £ s. d.
4½ Ins. { Crown	At per load . .	
4½ Ins. { Crown Brack	Do. . . .	
4 ,, { Crown	Do. . . .	
4 ,, { Crown Brack	Do. . . .	
3½ ,, { Crown	Do. . . .	
3½ ,, { Crown Brack	Do. . . .	
3 ,, { Crown	Do. . . .	
3 ,, { Crown Brack	Do. . . .	
&c. &c. &c.		

CONDITIONS OF CONTRACT.

1.—All the goods supplied under this contract to be imported direct from the Baltic; to be fresh cut, good, sound, merchantable, well conditioned, and subject to the approval of the Receiving Officers of the respective dockyards.

2.—The Dantzic Fir timber to be 11 inches square and upwards, meeting at 24 feet, and none to be shorter than 18 feet; the longest timber to be of the greatest scantling, and the spine to be seen from the butt to the top of each of the four sides. The whole to be fresh cut, and to be delivered in the following proportions of quality, viz.—60 per cent. to be best middling quality, 20 per cent. to be good middling quality, and 20 per cent. to be common middling quality. The common middling quality is not to exceed 13 inches square.

3.—The Dantzic Deals for decks of 4 inches thick to be not less than 9 inches in breadth; to average 8½ inches in breadth clear of sap, not any to be under 7½ inches, and to be 26 to 40 feet in length, averaging 33 feet. The Deals of 3½ inches, 3 inches, and 2½ inches thick to be not less than 9 inches in breadth, and to be not less than 7½ inches in breadth clear of sap, and 25 to 35 feet in length, averaging 30 feet. The Deals of 2 inches thick to be not less than 8½ inches in breadth, and to be not less than 7½ inches in breadth clear of sap, and 20 to 30 feet in length, averaging 25 feet. All the Deals to be delivered in the proportion of not less than 70 per cent. crown quality, and the remainder crown brack quality, to be clean, sound, yellow wood, converted in the country, of an equal thickness and square edged, and to be clear of sap, shakes, injurious knots, and defects.

4.—The Dantzic Deals for stages to be 2 inches thick, from 12 to 15 inches broad—the sap on the two edges not to exceed one-half of the breadth—and from 25 to 35 feet long, averaging 30 feet. The whole to be clean, sound, yellow wood, converted in the country, of an equal thickness and square edged, and to be clear of shakes, injurious knots, and defects.

5.—The Dantzic Oak thickstuff of 4½ inches thick, and planks of 4, 3½, and 3 inches thick, to meet at 32 feet, and none to be shorter than 24 feet, and to be from 10 to 13 inches broad, averaging 11 inches, clear of sap. The whole to be fresh, clean, free from defective wanes, cut regular, square edged and straight; the breadth for measurement to be taken clear of sap at the middle of the length; and 67 per cent. of each to be of first or crown quality, and the remainder of second or crown brack quality.

We occasionally obtain from Dantzic some Fir timber, which is known in the London market under the names

of Eliasberg and Saldowitz, from the districts in Russia whence it is drawn.

It is a very clean, sound, straight, and well-squared wood, of great average length, and more closely resembles the Riga Fir than any other in colour, texture, general appearance, and even in its defects, the heart and star-shakes being common to it. This wood cannot, therefore, be safely reduced to thin planks near the centre of the log without incurring the risk of some faulty pieces being produced at that part.

The classification for the market is similar to that of the Dantzic Fir, but there is very little of the common middling quality in it. When made up for sale it is generally arranged in parcels according to the size of the logs, those of 13 to 16 inches being kept distinct from those over 16 to 20 inches square, the latter being about the maximum size obtainable from the tree, while the lengths vary from 20 to 76 feet, and include many pieces of mast dimensions.

The employment of this description of Fir for mast purposes does not, however, appear to be contemplated by the shippers, and it is not, in my opinion, suitable for it, owing to its free character and liability to split in seasoning. The clean, straight, and even grain is, nevertheless, quite sufficient to recommend it to notice for furniture purposes, and its superior dimensions will always entitle it to preference over Dantzic or Riga Fir for works requiring long timber.

The prices of "Eliasberg" and "Saldowitz" Fir timber in general rule somewhat higher than that of the best Dantzic Fir.

There is also an inferior species of Fir brought in small quantities from Dantzic, and put upon the market under the name of Whitewood. It is white in colour

soft in character, and generally a little spongy near the centre.

It has a dull shade, and appears to be poor in quality, but, being a light, clean, straight-grained wood, and easy to work, it is suitable for packing-cases and for any ordinary purpose; it thus savesthe more expensive kinds of Fir. It is brought to this country in well-squared logs of rather superior dimensions to the Dantzic Fir.

CHAPTER XXIX.

FIRS—(*continued*).

RIGA FIR, A VARIETY OF THE *Pinus sylvestris*.

THIS timber takes its name from the port of shipment, although many of the forests from which it is drawn are very far back in the interior of Russia. It is the produce of a tree of almost perfectly straight growth, with lighter branches than are usually found in the Firs of the same species brought into Dantzic; it is consequently more free from injurious and objectionable knots.

The Riga closely resembles the Dantzic Fir timber in being whitish in colour and tinged slightly with red, but is rather lighter looking. It is tough, flexible, moderately strong, and scarcely so heavy as the Dantzic Fir, the respective specific gravities being about 541 and 582. It has a clean, fine, straight grain, and is a little shaky at the pith. It cannot, therefore, be converted into plank and board so profitably as the Dantzic and some other Firs. With this exception it is a very valuable wood, and is in great request for architectural works of every description; indeed, we find it used for nearly every purpose where light materials are required.

After the felling of this timber, it passes through the process of selecting and sorting over, the same as prevails in the Polish and Prussian forests and shipping ports, with a view to bring out the best pieces for masts, and the coarsest for railway sleepers. The logs of the intermediate class, when hewn into squares, yield dimensions of about 11 to 14 inches on the side, and from 20 to 45 feet in length. This timber is seldom classified as

best, good, or common middling, but is placed upon the market unsorted, and without any particular distinguishing brand upon it.

The selected spars generally come to us in a round state, under the name of Hand-masts. These are classed by the brackers at Riga alphabetically A to N, according to their size, the smallest being A, or 6 hands; that is to say, it measures 6 hands of 4 inches each, or 24 inches in circumference, taken at 4 feet in length from the butt-end of the spar: the largest being N, or 18 hands, or 72 inches in circumference. The lengths of these two sizes are respectively 36 and 74 feet. The following very plain rule prevails by which the established length to the number of hands is calculated, viz., rough spars for masts, of 6 to 9½ hands, the number of hands multiplied by 3, and 18 added, gives the length in feet; and spars of 10 to 18 hands, multiplied by 3, and 20 added, gives the length in feet; there being a small proportional increase of length required for vessels carrying the larger sizes.

The straightest and best spars have simply the bark taken off them, and the knots dressed smoothly, with perhaps a few feet in length at the butt-end hewn, to remove the swelling which often occurs at the base of the tree. Beyond this, owing to their generally fair and even growth, very little is required, and, as the alburnum or sap upon this description of timber is not usually more than about 1 inch in thickness, the waste sustained in their conversion into masts is altogether insignificant. These Riga spars (their generally small and medium sizes being considered) are about the best to be met with, and are in great favour with the mast-makers of the royal dockyards, though somewhat less so in the private trade.

There are, besides the hand-masts, many straight and fair-grown trees that measure less than 24 inches in circumference at the base, which are simply termed spars, or poles. There are also a few pieces occasionally met with that exceed the maximum size of the hand-mast, which are generally dressed approximately to an octagonal form, and then, as at Dantzic and elsewhere, they are called inch masts.

In ordinary specifications for building, it is stipulated the Fir is to be from Dantzic or Riga, as if they were equal in quality; but my experiments on Riga Fir, though not nearly so numerous as those on Dantzic, prove the former to be slightly inferior to the latter. Tables CXXII. to CXXVIII. and CXXIX. to CXXXII. show that the strength of the Riga is to that of Dantzic Fir as follows, viz. :—

Transversely as	150	:	219	or, it is weaker by about 31 per cent.			
Tensilely	,, 4051	:	3231	,, ,, stronger	,,	20	,,
Vertically	,, 5247	:	6948	,, ,, weaker	,,	24	,,

TABLE CXXIX.—FIR (RIGA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·10	3·00	580	524	664	145·00
2	1·00	·10	3·75	707	584	726	176·75
3	1·50	·10	3·30	498	518	577	124·50
4	1·50	·05	4·50	615	534	691	153·75
5	1·35	·10	3·85	677	570	712	169·25
6	1·15	·10	3·35	523	516	608	130·75
Total .	7·75	·55	21·75	3,600	3246	3978	900·00
Average	1·292	·092	3·625	600	541	663	150·00

REMARKS.—No. 1 broke a little short; 2 and 3 with fractures 9 inches in length; in 4, 5, and 6, the fractures were longer and splintery.

TABLE CXXX.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	584	17,920	4,480
8		524	12,320	3,080
9		570	19,600	4,900
10		534	14,980	3,745
Total . .	...	...	64,820	16,205
Average .	...	...	16,205	4,051

TABLE CXXXI.

Vertical or Crushing Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	3·250	9·000	16·	34·875
15, 16	3·125	7·875	—	—
17, 18	3·500	8·250	—	—
19, 20	3·750	8·500	—	—
21, 22	3·250	8·750	—	—
23, 24	3·000	8·250	—	—
Total . .	19·875	50·625	—	—
Average .	3·312	8·437	16·	34·875
Do. per in.	3·312	2·109	1·77	2·179

TABLE CXXXII.

Vertical or Crushing Experiments.

Number of the specimen.	Length of the specimen.	Scantling.	Area in square inches.	Weight of the specimen.	Specific gravity.	Crushed with	Ditto on 1 square inch.
	Inches.	Inches.		lbs. oz.		Tons.	Tons.
25	1			0 1	...	9·875	2·469
26	2			0 2	...	8·437	2·109
27	3			0 3½	...	11·500	2·875
28	4			0 4½	...	9·000	2·250
29	5			0 7	...	10·500	2·625
30	6			0 8½	...	11·250	2·812
31	7			0 10	...	11·125	2·781
32	8	2 × 2	4	0 10½	...	11·000	2·750
33	9			0 12	...	10·000	2·500
34	10			0 15	...	8·000	2·000
35	11			1 1	...	9·750	2·437
36	12			1 3	...	11·125	2·781
37	18			1 6	...	9·875	2·469
38	24			1 8½	...	6·875	1·719
39	30			2 5½	...	7·375	1·844
40	12			28 1	647	367·80	3·678
41	15	9½ × 10½	100	27 7	506	214·70	2·147
42	18			33 0	507	245·40	2·454
43	21			48 3	634	245·40	2·454
44	18			46 6	646	307·00	2·784
45	21	10½ × 10½	110·25	54 11	654	307·00	2·784
46	24			55 4	577	279·20	2·532
47	27	12 × 12	144	85 0	604	378·72	2·630
48	30			92 6	593	396·28	2·752

E = 752420. S = 1575.

The Riga is of slower growth than the Dantzic Fir, the difference being about 0·4 layers per inch in diameter (*vide* Table II.); this, in view of the theory previously set up, indicates that it is inferior to the Dantzic Fir.

Contracts for the supply of Riga Fir timber, and hand-masts for the royal navy, are made annually; the quantities of each kind varying according to the requirements of the several dockyards. They are received under the following specification and conditions, viz., the timber at per load of 50 cubic feet, and the hand-masts at each.

CONDITIONS OF CONTRACT.

All the goods supplied under this contract to be imported direct from the Baltic; to be of the best quality, fresh cut, good, sound, merchantable, and well conditioned.

The Riga Fir timber to be 11 inches square and upwards, averaging at least 12 inches, meeting in length at 24 feet, and none to be shorter than 18 feet; the longest timber to be of the greatest scantling, and the spine to be seen from the butt to the top on each of the four sides.

The Riga hand-masts to be of the dimensions specified, straight grown, and free from heart-shake and injurious knots. One-third of all the masts of 9 hands and under to be 4 feet longer than the prescribed length.

TABLE CXXXIII.

SPECIFICATION FOR HAND-MASTS (RIGA*).

—	Hands.	Length.	Diameter.	Distance from butt, 8″ to a hand.	Diameter.	Distance from top, 4″ to a yard.
		Ft. in.	Inches.	Ft. in.	Inches.	Ft. in.
N	18	74 0	22⅞	12 0	15¼	8 2
M	17½	72 6	22¼	11 8	14⅝	8 0
	17	71 0	21⅝	11 4	14¼	7 10
L	16½	69 6	21	11 0	14	7 8
	16	68 0	20⅜	10 8	13½	7 6
K	15½	66 6	19¾	10 4	13¼	7 4
	15	65 0	19⅛	10 0	12¾	7 2
I	14½	63 6	18½	9 8	12⅜	7 0
	14	62 0	17⅞	9 4	11⅞	6 10
H	13½	60 6	17¼	9 0	11½	6 8
	13	59 0	16½	8 8	11	6 6
G	12½	57 6	15⅞	8 4	10¾	6 4
	12	56 0	15¼	8 0	10⅛	6 2
F	11½	54 6	14⅝	7 8	9¾	6 0
	11	53 0	14	7 4	9⅜	5 10
E	10½	51 6	13⅜	7 0	8⅞	5 8
	10	50 0	12¾	6 8	8½	5 6
D	9½	46 6	12⅛	6 4	8	5 2
	9	45 0	11⅜	6 0	7⅝	5 0
C	8½	43 6	10⅜	5 8	7¼	4 10
	8	42 0	10⅛	5 4	6¾	4 8
B	7½	40 6	9½	5 0	6⅜	4 6
	7	39 0	8⅞	4 8	5⅞	4 4
A	6½	37 6	8¼	4 4	5½	4 2
	6	36 0	7⅝	4 0	5	4 0

* The above Specification will serve, with a slight modification of the hands to the length, for Dantzic Fir, Canada Red Pine, and also for Virginia Pitch Pine, due regard being paid to the difference in the quantity of sap-wood on each compared with Riga Fir. Hand-masts are frequently sold in the private trade at per load.

CHAPTER XXX.

FIRS—(*continued*).

THE SWEDISH FIR TREE

Is, as its name indicates, a native of Sweden, where it is very abundant, and attains, under favourable circumstances, a height of from 50 to 80 feet, with a circumference of from 4 to 5 feet; it yields timber in logs of 20 to 35 feet in length by 10 to 16 inches square. From the smaller trees, deals 3 inches thick, by 7 to 9 inches broad, and 12 feet and upwards in length, are obtained.

The wood is of a yellowish-white colour, soft, clean and straight in the grain, with only small knots, and very little alburnum or sap-wood on it. Of late it has been in great request for common building purposes, as as it is about 30 per cent. cheaper than Dantzic, and 15 to 18 per cent. cheaper than Riga Fir timber.

Swedish Fir is liable to the heart and star shakes, and not unfrequently the cup-shake. On this account it is not suitable for conversion into board for joiners' work, but only for the rougher and more ordinary works in building operations. This species of Fir is of very slow growth, and, during the early stage of its existence, it makes wood at only about half the rate of the Dantzic, Riga, and Polish Firs, but gains slightly upon this rate as it approaches maturity.

In consideration of the defects mentioned, there is little to recommend the Swedish Fir to favourable notice, beyond the fact of its being cheap and suitable for the coarser purposes in carpentry.

About 3,500,000 Swedish deals, 7,000 loads of timber, and 18,000 fathoms of firewood, were imported into London in 1874, besides a large quantity of boards for flooring, &c., &c.

THE NORWAY FIR TREE

is of straight growth and small dimensions, and balks of about 8 or 9 inches square only are produced from it, but even these are not now shipped in any considerable quantity for the English market.

The Norwegians appear to find it most advantageous to convert their Fir timber (which is generally of a coarse description and inferior in quality) into battens of 6 to 7 inches in breadth, by less than 3 inches in thickness, and into prepared flooring and match-boards, which are sold by the "square" of 100 superficial feet of 1 inch thick. They also produce a few deals of 3 × 9 inches, varying in length, for exportation; and, as the whole of these are manufactured and sold at a very cheap rate, they pass readily into consumption for the building of the lowest and poorest class of houses.

Norway supplies, in addition to the timber, deals, and battens, considerable quantities of small spars, and Fir for firewood, to the London market.

THE SPRUCE FIR TREE (*Abies excelsa*)

is very abundant upon the mountain slopes in Norway, and prefers generally a damp clayey soil to bring it to the greatest perfection. In such situations, it frequently

reaches to a height of 80 to 130 feet, with a circumference of 3 to 5 feet. It may also be found upon most of the mountainous parts of the North of Europe, and is abundant in North America. The Spruce Fir is an evergreen, and assumes in open ground a beautiful pyramidal form, with the lower branches drooping nearly to the ground; the leaves are solitary and very short, and the cones long and pendulous, with the scales thin at the edges. It will thus be easily distinguished from the Pines, which have their leaves clustered in twos or threes.

The wood is white in colour, straight and even in the grain, tough, light, elastic, and more difficult to work than Pine, owing chiefly to the excessive hardness of the small knots which are frequently found in it. When cut into deals it is somewhat disposed to warp, unless carefully weighted in the stacks or piles during the process of seasoning. The shrinkage is inconsiderable, and the sap, though generally only of moderate thickness, varies from half-an-inch, in some trees, to 2 or 3 inches in others.

The Spruce Firs are not suitable for the best-finished carpenters' or joiners' work, but for framing and the coarser descriptions of work it may be used with advantage, and also in ships for any of the fitments in store-rooms, for lockers, shelves, mess-tables, &c.

The trees are generally straight, and being strong as well as elastic, they are admirably suited for making the small spars required for ships and boats. They are also in great request for ladders and scaffold poles, and for stage-making in ship-yards.

Norway spars are known under the following designations, and are classified for the navy contracts according to their size, thus :—

TABLE CXXXIV.

SPECIFICATION.

No.	Description.	Length.	Diameter.	From the butt.	Diameter.	From the top.
		Feet.	Inches.	Ft. ins.	Inches.	Ft. in.
5	Cants ...	34 to 36	7 to 6½	at 3 4	4	at 3 8
4	Barlings ...	31 ,, 33	6 ,, 5½	2 8	3¼	3 4
3	Booms ...	28 ,, 30	5 ,, 4½	2 0	2½	3 0
2	Middlings...	23 ,, 26	4 ,, 3½	1 4	1⅜	2 8
1	Smalls ...	19 ,, 22	3 ,, 2	0 8	1	2 4

These spars are usually bought for the navy at a price each, but for the private trade they are not unfrequently sold at per foot run.

Nothing is done to these trees after they are felled, beyond removing the small branches, cutting off the top, and making the ends even, to prepare them for the market. They are, therefore, brought to us with the bark on, and are measured over all. It is well, however, to take the bark off if they are not required for immediate use, otherwise they will suffer injury from the attack of a small worm which after a few months appears between the bark and the alburnum.

The Spruce Fir has a further intrinsic value in yielding a resinous fluid which constitutes the foundation for the manufacture of pitch. The Spruce Firs are all of very slow growth, and not so durable as Pine.

There are at least three kinds of Spruce in North America, namely, the Hemlock (*Abies Canadensis*), which has small, pointed, pendulous terminal cones, and thin, flat leaves; the Black or Double Spruce (*Abies nigra*), with dependant, egg-shaped cones, the scales being waved and jagged at the edges; and the White or Single Spruce

(*Abies alba*), which has longer cones, spindle-shaped, also dependant, with the scales smooth and entire on the edge.

The White Spruce are the only deals shipped to this country from Canada as a clearly-defined class, all others being simply known here as Canadian, St. John's, &c. Spruce.

The London market was supplied with about 1,100,000 Spruce deals in 1871, 1,080,000 in 1872, 2,000,000 in 1873, and the immense quantity of 2,300,000 pieces in 1874, prepared generally in dimensions of 3 inches thick, 9 inches broad, and 12 to 21 feet in length. The bulk of these were sorted by brackers previous to shipment into first, second, and third qualities. Those of the first quality are perfectly clean, sound, and free from knots, sap, and defects; the second quality are also sound, and tolerably clean, but include deals with a few knots and some sap upon the edges; while the third quality includes and admits all the faulty and coarser descriptions of deals, and some of them are very rough indeed.

As a rule, there is no brand other than a red chalk mark drawn once, twice, or thrice across the deal, to distinguish between the several qualities, and it is necessary that a careful inspection should be made before purchasing them. The relative values of the Canadian and New Brunswick Spruce deals in the London market are about as follows, viz., the 1st quality Canadian is to 1st quality New Brunswick Spruce as 1·0 : ·82; the 2nd and 3rd quality Canadian is to 2nd and 3rd New Brunswick Spruce as 1·0 : ·90; and these figures indicate approximately the difference in their respective qualities. All these deals are employed extensively in carpentry, ship, and engineering works.

TABLE CXXXV.—SPRUCE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·06	6·25	696	451	926	112·75
2	1·20	·05	5·00	719	485	890	121·25
3	1·15	·04	3·75	556	510	654	127·50
4	1·30	·07	5·75	709	490	867	122·50
Total .	4·90	·22	20·75	2680	1936	3337	484·00
Average	1·225	·055	5·187	670	484	834	121·00

REMARKS.—No. 1 broke with about 12 inches length of fracture; 2, 3, and 4 with only a little less.

TABLE CXXXVI.

Tensile Experiments.

(Dimensions of each piece, 2 × 2 × 30 inches, s.g. 484.)

——	No. 5.	No. 6.	No. 7.	No. 8.	Total.	Average.
Weight the piece broke with	lbs. 13,104	lbs. 19,040	lbs. 13,440	lbs. 17,360	lbs. 62,944	lbs. 15,736
Direct cohesion on 1 square inch	3,276	4,760	3,360	4,340	15,736	3,934

TABLE CXXXVII.

Vertical or Crushing Strain on cubes of 2 inches.

No. 9.	No. 10.	No. 11.	No. 12	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
9·00	8·875	7·75	8·875	8·75	8·75	52·00	8·666	2·166

E = 771800. S = 1759.

The trade in foreign deals, battens, boards, &c., from the countries in the North of Europe, is very great, and there were imported into the United Kingdom, in 1874, 2,800,000 loads; in 1873, 2,450,000 loads; in 1872, about 2,300,000 loads; as compared with 2,140,000 loads in 1871; 1,900,000 loads in 1870, and 1,380,000 loads in 1866. Large as these quantities are, they seem likely to go on increasing, and will probably continue to do so, until the supply is exhausted. Sweden has contributed the larger portion of these, Norway and Russia come next, and are nearly alike in quantity; Prussia follows, and Finland supplies least of all.

To particularise and describe the various shades of difference to be found in the quality of these deals, battens, &c., would be next to impossible, drawn as they are from so many ports of shipment in each of the countries referred to; but, taking them in a general way, the order of quality would stand, first or best with Prussia, then with Russia, Sweden, and Finland, and lastly, with Norway. Each of these countries classify their goods by first and second, and sometimes third quality, the respective distinctions of classes being based upon the perfection or otherwise of the manufacture, and freedom from shakes, sap, or defects.

From whatever source these deals are obtained, they are usually branded with some fancy mark, letter or device, as varied in character as the names of the different merchants who produce them. These trade-marks are all liable to be changed, and the purchaser, unless he can make the selection for himself, must rely upon the reputation and integrity of the firm he treats with, for obtaining the particular article he may require.

The following are samples of the trade-marks in present use upon deals and battens:—

TABLE CXXXVIII.

Where from.	First Quality.	Second Quality.	Third Quality.
Christiania	H+G; H*M; AOH; AHO; A+T; GAH.	HMH; AHA; A+H; HSG; V+V; LM.	H+H; T+I; T+B; B+K; L+B.
Dram	T+H; HK; O+H; E+T; HB.	N+N; KW; TH; DD; OO; B; T*H; SH; C&Co; T; OH; SK; E+T; E*T.	IW; C; BB; H; B; K; HH; TT; H+H.
Fredrikstad	FAA; TWS; H+B; H*B; JNJ; W+G; W♚G; W♚♚♚G.	A+F; S—bak; HHH; W+W; MM; TS.	HBT; SS; MMM.
Fredrikshald	SFA.	SFB.	FSC.
Gefle	C♚B; A♚S; G♚H; M♚S; EAB; KAB; KHB; SKB; GH+A.	The same marks as first quality; colours may vary.	NAS; C+B; A+S; BL; DOM; FAB; HAB; G+H; B+B; GH+B.
Hernosand	S♚W; H♚A; WAYA; J♚N; HC.	Ditto, ditto. Ditto, ditto.	S+W; M♚S; N+N; H*A; W&Co.
Hudikswall	HC; H♚H.	H+H; H*H; H.	PP; FB; HHH.
Husum	DB & Co.	DB & Co.	DDD.
Lulea	GM.	GH.	GT.
Sundswall	H♚H; A♚A; A♚B; E*A; N+W.	The same marks as first quality; colours may vary.	A*A; A*B; E+A; ALB; NW; NAS.

CHAPTER XXXI.

LARCHES.

THE LARCH TREE (*Abies Larix*).

THIS is a deciduous tree, and is considered by many eminent botanists to be of the same genus as the Spruce; the leaves grow in clusters and spread out in a brush or mop-like form, and in the spring, when quite fresh, they have a beautiful light-green tint, which make them very remarkable among other trees. The cones are of an oblong shape, and somewhat blunt.

The Larch is a native of the European Alps and the Apennines, and is found abundantly in Russia and in Siberia. It thrives in dry, elevated, and almost barren land, and for this reason is perhaps the most profitable tree that can be planted in a poor soil. It grows at about the same rate, in such situations, as the *Pinus sylvestris* does in more fertile localities, making 1 inch of wood in about 5½ years, or 2 feet in diameter in about 130 years (*vide* Table II., p. 18).

In Scotland it has been planted by the Duke of Athol and others in immense quantities, and it has been stated that at elevations of upwards of 1,500 feet above the sea level, trees have been felled when only eighty years old that have yielded each from five to six loads of

timber, while in less elevated positions the produce is said to have been even more satisfactory.*

The wood is of a yellowish-white colour, tough, strong, and occasionally a little coarse, but is generally straight and even in the grain. It works up tolerably well, and is considered to be very durable, but has the serious drawback of excessive shrinkage, with a tendency to warp in seasoning.

The Larch tree yields the Venice turpentine of commerce, which is procured in abundance from the trunks of old trees; the bark also is of considerable value to the tanner. The Siberians make use of the inner bark, mixed with rye-flour, for preparing a sort of leaven, whenever the ordinary supply of the better article fails them.

The Italian Larch timber, some time since imported into this country, was only of moderate dimensions, a little curved at the butt or root end, and straight from about the mid-length, tapering rather quickly towards the top. This timber was generally free from heart-shake, and very solid about the pith, clean and even in the grain over the lower part, but coarse and knotty higher up; consequently, though not well adapted for the ordinary works in carpentry, it was very suitable for those parts of the frames of ships in which a light material is considered desirable.

It seems probable that the timber above referred to was especially selected for ship-building purposes, but

* To test the durability of the Scotch Larch, H.M.'s ship "Athol" was built of this timber in 1820, and about the same time the "Nieman," also a ship of war, was built of Baltic Fir. The former lasted for a long time without any extensive repairs, but the other decayed very rapidly, and from this comparison the superiority of the Scotch Larch over Fir, for durability, was considered to be pretty well established.

there are, doubtless, many Larch trees of straight growth in Italy, since it is stated on good authority that the greater number of the houses in Venice are built upon piles of this timber, particularly those of which the supports are alternately exposed to wet and dry; many of these piles, after being in place for ages, are said not to have the least appearance of decay.

This wood evidently stood in high favour in early times. Julius Cæsar—who called it "Lignum igni impenetrabile," because he could not burn it with the same facility as other timber—used it for every purpose whenever he could obtain it. Tiberius Cæsar brought it over long distances from the forests of Rhætia for the reparation of several bridges, and Pliny relates that a Larch tree, measuring 120 feet long and 2 feet in thickness, from end to end, was intended to be used in one of these. It was, however, preserved for a long time as a curiosity, and ultimately employed in the building of a large amphitheatre.

The Polish Larch tree is generally of straight growth, and of dimensions rather exceeding the Italian variety. It is also coarser in the grain, more knotty, and has a larger amount of alburnum, or sap-wood.

The Russian Larch tree attains dimensions superior to either of the foregoing descriptions. A cargo of this timber, very long and straight, was imported into this country a few years since from the district of the Petchora, a river flowing from the Ural Mountains into the Arctic Ocean.

This parcel passed into the hands of the Government for the service of Woolwich Dockyard, where a portion of it was employed experimentally in ship-building, for

deck and planking purposes (for which it was judged to be especially suitable), in place of Baltic Fir and Pine timber.

It disappointed, however, the expectations of the officers, as it was soon found to shrink so excessively, that it was impossible to keep it weather or water-tight; in consequence of this it was removed from the ship. The remains of the parcel therefore passed into conversion for the most common and ordinary services, and, of the board produced, much was used for berthing in the timber sheds. It stood the test of exposure in such situations for fully eight years without showing any signs of decay, but exhibited a disposition to warp and shrink far exceeding that of any other wood in present use in carpentry.

The subjoined Table, No. CXXXIX., shows that the Russian Larch is slightly deficient in transverse strength, as compared with the Firs and Pines; but, otherwise, it is above their average.

TABLE CXXXIX.—LARCH (RUSSIAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·15	4·5	743	688	648	185·75
2	1·5	·15	5·0	714	697	615	178·50
3	1·5	·00	4·75	708	645	658	177·00
4	1·75	·25	3·85	504	618	489	126·00
5	1·75	·15	4·15	568	647	527	142·00
6	1·65	·35	3·75	519	583	534	129·75
Total .	9·40	1·05	26·00	3756	3878	3471	939·00
Average	1·566	·175	4·33	626	646·3	578	156·5

REMARKS.—All broke with a moderate length of fracture.

TABLE CXL.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	618	14,000	3,500
8		645	13,440	3,360
9		647	19,936	4,984
10		688	19,880	4,970
Total .	...	2598	67,256	16,814
Average .	...	649	16,814	4,203

TABLE CXLI.

Vertical Experiments on Cubes of

Number of the specimens.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	2·875	10·750	19·625	42·75
15—18	2·750	10·875	19·500	42·50
19, 20	2·875	10·750	—	—
21, 22	3·000	10·375	—	—
Total . .	11·5	42·75	39·125	85·25
Average .	2·875	10·687	19·562	42·62
Do. per in.	2·875	2·672	2·174	2·663

E = 649130. S = 1643.

North America also produces a species of Larch, the well-known Hackmatack (*Larix Americana*); it is said to be tolerably abundant, and is found to range from the mountains of Virginia to Hudson's Bay.

In deep forests it sometimes attains a height of 60 and

even 80 feet, but it is generally of small dimensions. The wood is of a reddish-grey colour, moderately hard, heavy, strong, and as durable as Oak. It is extensively employed in America in the framing, and generally in the construction of ships. Great curves and knee-pieces, however, can only be obtained from the spurs of the root and from the branches.

The American Red Larch (*Larix microcarpa*) is less abundant, and as a building wood is not much known. It is believed to be equal in strength and durability to the *Larix Americana*, with which, indeed, it occasionally passes without being detected.

CHAPTER XXXII.

CEDARS.

THE CEDAR TREE (*Abies Cedrus*), THE CEDAR OF LEBANON,

Is found upon Mount Lebanon, the Taurus, and also upon many of the mountains in Asia Minor.

It is a very stately and majestic evergreen tree, with heavy wide-spreading branches thrown out horizontally from low down the stem, bearing clustered leaves and erect obtuse oblong cones. Very extraordinary accounts have been given of the longevity of these trees, but these, I think, should be received with some little reserve.

It is stated in a small work on useful and ornamental planting, that at Highclere Park, in Hampshire, the Earl of Caernarvon planted seeds in 1739, from a cone gathered upon Mount Lebanon. Only two germinated, which, after being planted out, remained rather stunted, and without showing any signs of vigour. In 1767 they were transplanted into a poor soil, in a bleak situation, being at that time 17 inches in girth at one foot from the ground, and from that date their growth was considered to be satisfactory.

No. 1 in	48	years measured	35	inches in girth at	3	feet from the ground.
,,	73	,,	82	,,	3	,,
,,	93	,,	111	,,	3	,,
No. 2 in	48	,,	22	,,	3	,,
,,	73	,,	72	,,	3	,,
,,	93	,,	102	,,	3	,,

These two Cedar trees, therefore, when 93 years old,

measured respectively about 37 and 34 inches in diameter, and were making wood at the rate of 1 inch of diameter in about 2½ years. If this rate of growth is applied to the largest of the trees which Maundrell mentions that he saw upon Mount Lebanon, it would show them to be only about 350, or, at the most, 400 years old; and it is probable that this is somewhere about the limit of age which the Cedar trees attain, and not 3,000 years, as has been asserted.

The rapid growth of the Cedar tree is borne out by the careful examination of some logs brought from Honduras, which were found to exhibit a rate of growth even quicker than those mentioned, the concentric rings showing that 1 inch of wood diameter was made in rather less than two years.

We know very little of the quality of the timber of the Cedar of Lebanon; it is too scarce to find its way in any quantity into the markets of this country.

THE CUBA, HONDURAS, AND MEXICAN CEDARS

are varieties of the *Cedrela odorata*, but in their nature and condition of growth are very different from the *Abies Cedrus* of Lebanon, which flourishes best with plenty of room and in open grounds, whilst those of the West Indies and Central America appear to prefer a closer situation, and attain the greatest perfection in the forests. Many of these are very fine trees, capable of yielding well-squared logs of timber, 12 to 24 inches on the side by 18 to 40 feet in length, and even these dimensions are occasionally exceeded. Smaller timber is brought in considerable quantities into the market, the whole finding a ready sale among cabinet-makers and with those engaged in the manufacture of cigar-boxes and similar articles.

The wood is reddish-brown in colour, open and straight in the grain, very porous, soft and spongy in the centre, of light weight, and rather brittle; large and injurious heart and cup-shakes frequently occur in it. It is deficient in strength, whichever way it is tried, but it works up easily, shrinks only moderately, and stands exceedingly well when seasoned. It is, therefore, of great value to the modeller, the carver, the toy-maker, and the general dealer in light and small wares. Large scantlings cannot, however, be worked out of it for framing in carpentry, neither is it suitable for such employment.

Cedar timber has long enjoyed the reputation of being durable; and there is no doubt that Solomon obtained the *Abies Cedrus* for employment in the fitments, if not in the more solid structure, of the Temple at Jerusalem. The wood has a pleasant though peculiar odour, which is obnoxious to insects and vermin, and articles made of this material are practically free from their attacks.

The specific gravity of well-seasoned Cuba Cedar is about 439. The specific gravities of moderately-seasoned Cuba, Mexican, and Honduras Cedars are respectively 564, 640, and 664.

THE BERMUDIAN CEDAR (*Juniperus Bermudiana*) is very small, and much lighter than that of Cuba. It was tried experimentally, a few years since, in the building of several brigs and schooners in the royal dockyards, but with only partial success, and the use of it was soon discontinued. It is used in the Bermudas for the building of boats and small vessels, and is in request in this country for the making of pencils.

The Cedar of Florida is similar in quality and

texture to the Bermudian, and is well adapted for the same kind of employment.

The Spaniards formerly used Cedar to a great extent in ship-building; and the "Gibraltar" and other large ships of theirs were found, on being taken to pieces, to have much of this wood in them, in a sound state.

Cedar is found in India, Japan, Australia, and Van Diemen's Land.

The same rule prevails in the market with reference to the sale of Cedar as with Mahogany, namely, that of deducting about one-third from the calliper measurement for irregularity of manufacture, shakes, defects, centres, saw-kerfs, &c.

Pencil Cedar is classed No. 3; Red Cedar, No. 6; and White Cedar, No. 17, among timbers used in ships, in Lloyds' rules for ship-building.

TABLE CXLII.—CEDAR (CUBA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	2·25	·05	4·35	530	372	855	132·50
2	2·35	·30	4·35	555	386	863	138·75
3	2·00	·25	4·25	630	530	713	157·50
4	2·25	·25	4·25	560	504	666	140·00
5	2·25	·35	4·35	550	416	793	137·50
6	2·50	·35	4·65	535	425	755	133·75
Total .	13·60	1·55	26·20	3360	2633	4645	840·00
Average	2·266	·258	4·366	560	439	774	140·00

REMARKS.—All broke with a short fracture.

TABLE CXLIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	416	11,760	2,940
8		425	11,200	2,800
9		504	12,320	3,080
10		530	10,640	2,660
Total . .	...	1875	45,920	11,480
Average .	...	469	11,480	2,870

TABLE CXLIV.

Vertical or Crushing Strain on cubes of 2 inches.

No. 11.	No. 12.	No. 13.	No. 14.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
8·00	7·75	9·00	7·25	32·00	8·00	2·00

E = 449710. S = 1470.

CHAPTER XXXIII.

PINES.

THE RED PINE TREE (*Pinus resinosa*, Aiton).

IN an official report, published in Boston in 1846, on the trees growing naturally in the forests of Massachusetts, it is stated that "The bark of this tree is much less rough than that of the Pitch Pine, and consists of rather broad scales of a reddish colour. The long leaves are in twos, and the cones are free from the bristling, rigid, sharp points which distinguish those of the Pitch Pine. It may also be distinguished at a distance by the greater size and length of the terminal brushes of leaves. It is known in New England by the name of Norway Pine, although it is entirely different from the tree so called in Europe, which is a kind of Spruce; it is known in Canada as Red Pine."

This description of timber, unlike the Dantzic and Riga Firs, which take their title from the port of shipment, derives its name from the reddish colour of its bark.

It is a native of the United States and Canada, in North America, where it attains a height of from 70 to 100 feet, with a circumference of from 4 to 5 feet. It is more slender than the Pitch Pine, and yields the timber

of commerce in logs of from 10 to 18 inches square, and from 16 to 50 feet in length. The tree is of erect growth, with a tendency to slight curvature at the butt or root end of the stem, and, like most other Pines and Firs, has numerous though not usually heavy branches.

The wood is white, tinged with yellow or straw colour; it is tough, elastic, moderately strong, and possesses a clean fine grain, which works up well, leaving upon the surface a smooth silky lustre. It is not apt to shrink, split, or warp much in seasoning, and, technically speaking, it stands well, which renders it a choice and very valuable wood for all kinds of construction, while in the domestic arts there need not be any limit to its application.

The Red Pine is very solid about the pith or centre of the log, and has but little alburnum or sap-wood. There is, therefore, only a small amount of loss in its conversion, even if reduced to planks and boards; while it can further be worked with great advantage in shipbuilding, for deck purposes, for cabin, and for other fitments.

With every season's fall of this timber there are a few rough spars selected for hand-masts, holding about the same dimensions as those obtained from Riga. These spars, however, are very few in proportion to the number of trees felled, owing to the fact before mentioned, that the trees are not generally quite straight, although fairly grown. On this account the selected spars nearly all require to be dressed to a straight form, and simply taking off the knotty tops of the trees and removing the bark is not sufficient to constitute the hand-mast of this species of Pine.

The surveyor and mast-maker will, therefore, find it necessary to examine these spars very carefully to ascer-

tain the amount of dressing to which they have been subjected, and whether or not the fibre has been cut or destroyed to a degree that would impair its trustworthiness for mast purposes. If the spar is found to be straight and free from injurious knots, and excessive dressing, it may be accepted as likely to do good service, the strength and elasticity of this wood comparing favourably with those of the Riga and Dantzic Firs.

The trees that remain after the spars are withdrawn are hewn into a square form, and have a small amount of wane left upon each angle (Fig. 28). They are also

FIG. 28*a*.

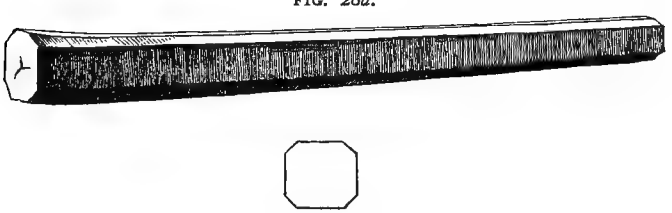

FIG. 28*b*.

dressed to follow the natural taper of the tree, which is rather more rapid and noticeable than in other Pines. No particular classification is made of this wood for the market, beyond the separation of the larger from the smaller or building scantlings, and the quotations of prices for the timber are generally for "large," or for "mixed," and "building" sizes.

The Red Pine of Canada is dearer than the Fir timber of the North of Europe by at least the difference in the cost of freight, and, hence, it does not find quite so ready a sale, the quality of the article to be employed in ordinary building operations not being so much a consideration as the quantity to be obtained for money.

TABLE CXLV.—RED PINE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·85	·15	4·50	590	536	660	147·5
2	1·75	·15	4·25	572	525	654	143·0
3	1·50	·10	3·25	588	576	612	147·0
4	1·65	·15	5·75	700	578	727	175·0
5	1·50	·10	5·50	724	552	787	181·0
6	1·75	·15	4·50	746	554	808	186·5
Total .	10·00	·80	27·75	3920	3321	4248	980·0
Average .	1·666	·133	4·625	653·33	553·5	708	163·33

REMARKS.—Nos. 1, 2, and 6 broke with a moderate length of fracture; 3, 4, and 5, rather short.

TABLE CXLVI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
7	2 × 2 × 30	536	11,200	2,800
8		525	11,200	2,800
9		552	11,200	2,800
10		554	6,832	1,708
11		578	13,300	3,325
12		576	11,200	2,800
Total .	...	3321	64,932	16,233
Average .	...	553	10,822	2,705

TABLE CXLVII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
13—16	2·375	8·000	21·875	34·00
17, 18	3·500	8·500	—	—
19, 20	3·250	8·250	—	—
21, 22	3·500	8·750	—	—
23, 24	3·750	8·375	—	—
25, 26	3·500	8·875	—	—
Total . .	19·875	50·75	—	—
Average .	3·312	8·46	21·875	34·00
Do. per in.	3·312	2·115	2·431	2·125

NOS. 27 TO 30.—Four pieces, each 2 × 2 inches, and respectively 1, 2, 3, and 4 inches in length, crushed with 9·375, 8·460, 8·250, and 9·50 Tons.

$$E = 588900. \qquad S = 1715.$$

Contracts are annually made for the supply of Canada Red Pine timber for the Royal Navy, according to the following specification and condition, namely :— The Red Pine timber to be of the first quality, fresh cut, good, sound, merchantable, and well-conditioned, from 11 to 15 inches square, averaging 12½ inches, 20 feet and upwards in length, and the spine must be seen from the butt to the top on each of the four sides.

CHAPTER XXXIV.

PINES—(*Continued*).

THE YELLOW PINE TREE (*Pinus Strobus*).

THIS tree occupies a very wide range in North America, and is found to spread from near the Saskatchewan River, in about 54° N., to the ridges of the Alleghany Mountains in Georgia, and from Nova Scotia to the Rocky Mountains. It is found in every part of New England, growing in every variety of soil, but flourishing best in a deep, moist, loamy sand.

In England it is called by botanists the Weymouth Pine, in compliment to Lord Weymouth, who first introduced it into this country; but in America it is commonly known as the White Pine, while the timber it yields is best known in commerce as the Yellow Pine. This tree may be distinguished by its leaves growing in tufts of five, by its very long cones composed of loosely-arranged scales, and, when young, by the smoothness and delicate light-green colour of the bark. The trees are of erect growth and noble dimensions, many of them being 100 to 150 feet in height, and from 9 to 12 feet in circumference.

The wood is of a pale straw colour, soft, light (the specific gravity being only 435), and moderately strong. It has a clean, fine grain, works up with a smooth and

silky appearance, and is, on this account, in great favour with carpenters. It is very valuable for every description of joinery, where lightness may be desirable, and may be applied with advantage to many ornamental uses in both naval and civil architecture. For more substantial works of construction, it is not, however, considered to be so well adapted, as it is not sufficiently strong or durable for employment in them.

In every season's felling of the Yellow Pine trees, the straightest, longest, and finest pieces are sorted out and dressed or hewn nearly to the octagonal form; they are then called "Inch masts," and these rough spars serve for employment for the lower masts, yards, and bowsprits of ships.

It is essential to the qualification of the stick for mast, yard, or bowsprit purposes, that it be straight, sound, free from sudden bends and injurious knots. Further, it is important that the grain be straight, and especially it should be free from any spiral turn, as timber of that growth is liable to warp or twist out of shape after being worked. Nearly all the lower masts, yards, and bowsprits of large ships are made of Yellow Pine; but, for the lower masts of small vessels, and generally for the top-mast, topsail-yards, and other light spars where the strain is often sudden and great, this description of Pine is not strong enough, and is therefore seldom employed.

The employment of Yellow Pine for large spars is chiefly owing to the difficulty experienced in obtaining the stronger Pines of sufficiently large dimensions, and it is only since the introduction of the "Douglas Pine" spars from the Oregon district of Columbia, that they have been in some measure superseded. Still, the Yellow Pine wood, when made into masts, has gene-

rally proved equal to the strains brought to bear upon it; the stays, shrouds, and other rigging being quite sufficient to hold it against any ordinary amount of pressure.*

After the spars have been withdrawn from each season's fall of trees, the remainder are hewn into a square form, producing logs varying from 14 to 26 inches square, and from 18 to 40 feet in length (Fig. 29). These pass through a sorting for quality, to suit the market, but there are no official brands by which the surveyor could at once identify them. Good, sound, practical judgment is therefore most essential for making a selection of this wood.

FIG. 29.

Occasionally we see quoted some "waney" timber for board purposes, or "waney board timber." These logs are not so perfectly hewn or squared as the ordinary timber, and are usually short butts of trees, which are very clean in the grain, free from knots, and solid at the centre. These are probably procured from fine trees that

* Masts made of Yellow Pine can seldom be relied upon after eight or ten years' work, especially if they have been used in the tropics, where the intense heat and rains deteriorate them very rapidly. Every care should therefore be taken to preserve them, first by painting them only after thorough seasoning, and then at intervals of a year or so. The covers at the wedging decks should also be carefully looked to, and kept in good condition, to prevent damp from affecting the mast at that part. The introduction of iron for the lower masts of ships is now fast superseding the use of wood, both in the royal and the mercantile navy.

have been broken in their fall, and are doubtless about the best that can be obtained for conversion into board.

In addition to the masts and timber, a few deals are imported. These are cut 3 inches thick, and vary in breadth from 9 to 24 inches, and occasionally even to 32 inches. In length they vary from 10 to 20 feet. They are sorted in Canada into three parcels, and designated first, second, and third quality, according as they are found free from knots, sap, defects, &c., &c., or otherwise. They are further denominated "bright," when passed direct from the saw-mills to the craft for shipment, in contradistinction to others, termed "floated," which are often brought over long distances on rafts, and get a little discoloured in their transit. They are commonly sold at per 120, St. Petersburg standard, and the price of the "floated" usually stands depreciated in the market to the extent of about 10 or 12 per cent. below the price of "bright" deals. A simple red chalk mark, thus—I., II., and III., drawn across the middle or side of the deals, is the only distinguishing brand they have to denote their quality.

Yellow Pine timber is subject to the cup and heart shake defects, and there is also a slight degree of sponginess about the centre or early annual layers of the older trees, which detracts a little from their value. Further, the top end of the logs are often coarse and knotty, which renders that part unfit for conversion into small scantlings; but, otherwise, it is a good and profitable description of timber for use, in substitution for the heavier and harder Pines.

The subjoined tables of experiments on the strength of Yellow Pine will afford a means of comparison with other species.

TABLE CXLVIII.—YELLOW PINE (CANADA).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inches.	Inches.	lbs.			lbs.
1	2·00	1·75	4·50	630	424	891	157·5
2	2·00	1·65	5·00	636	432	882	159·0
3	2·00	1·85	4·50	684	464	884	171·0
4	1·75	1·65	4·50	660	444	892	165·0
5	2·25	2·00	3·75	552	435	761	138·0
6	2·75	2·10	5·75	598	411	873	149·5
Total .	12·75	11·00	28·00	3760	2610	5183	940·0
Average	2·125	1·833	4·66	626·6	435	864	156·66

REMARKS.—The whole of these broke with a moderate length of fracture and splintery.

The above-mentioned specimens were all of good quality, well seasoned, and taken from trees of 6 to 8 feet in circumference. It will be observed that the specific gravity and breaking strains varied only in a slight degree. By the formulæ—

$$E = 309240. \qquad S = 1645.$$

Experiments were also made to test the transverse strength of a series of seven pieces (Table CXLIX.) cut from a plank 2 inches thick, taken out of the middle or centre part of the butt-end of a tree, the centre piece ⊙ being made to include the pith (Fig. 30).

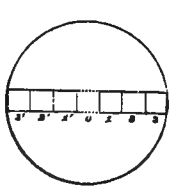

FIG. 30.

We are thus enabled to compare the strength of the earlier and the later growth of this wood.

TABLE CXLIX.—YELLOW PINE (CANADA).

Transverse Experiments.—2nd Example.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inches.	Inches.	lbs.			lbs.	lbs.	
7. 3	1·50	·50	4·25	508	568	537	127·0	2660	3. 22
8. 2	1·25	·50	4·25	562	600	562	140·5	2800	2. 23
9. 1	1·50	·50	2·25	480	537	536	120·0	2485	1. 24
10. ⊙	2·25	1·10	2·75	360	430	502	90·0		⊙
11. 1′	1·85	·85	3·00	480	588	490	120·0	2730	1′. 25
12. 2′	1·90	·90	4·25	512	568	541	128·0	2800	2′. 26
13. 3′	1·75	·65	3·00	478	566	507	119·5	3080	3′. 27
Total	12·00	5·00	23·75	3,380	3857	3675	845·00	16,555	—
Aver.	1·714	·714	3·393	482·85	551	525	120·71	2759	—

The mean results of the experiments are as follows, viz. :—

The centre piece ⊙ s.g. 430 broke with 360 lbs. E = 785170. S = 945
,, next pieces 1 and 1′ ,, 562 ,, 480 ,, E = 902950. S = 1261
,, 2 ,, 2′ ,, 584 ,, 537 ,, E = 577020. S = 1425
outer ,, 3 ,, 3′ ,, 567 ,, 493 ,, E = 822740. S = 1294

The mean of the 7 pieces being E = 902950 and S = 1267.

In the above example, there is something like a

direct proportion existing between the specific gravity and the strength, the densest wood having borne the greatest strain before breaking. Instead, however, of this point of density lying at the centre of the tree, as in the specimens of Oak that were tested in a similar manner, we find it, as is generally the case with other woods, about midway between the pith and the outer layers of duramen.

The results, if compared with the mean of the first-mentioned set of experiments on Yellow Pine (Table CXLVIII.), which were upon pieces taken from several trees, show that the tree from which the seven specimens were obtained possessed a little less strength, and rather less elasticity, than the former; but then it must be borne in mind that they were selected pieces, and probably did not include the weaker wood of either the oldest or the newest layers.

Further experiments were tried on six out of seven of the specimens, to ascertain their relative tensile strength (Table CLXIX., column 9). The following are the average results :—

The pieces	1	and	1′	s.g.	562	broke with	2,607	lbs. on the square inch.
,,	2	,,	2′	,,	584	,,	2,800	,, ,,
,,	3	,,	3′	,,	567	,,	2,870	,, ,,

The centre piece ⊙ was not tried for tensile strength, as it was too much crippled under the transverse strain to be of any further value for experimental purposes.

The denser layers 2 and 2′, were not in this case quite so strong as 3 and 3′, which were of a less specific gravity.

TABLE CL.—YELLOW PINE (CANADA).

Transverse Experiments.—3rd Example.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inches.	Inches.	lbs.			lbs.	lbs.	
14. 4	2·00	·65	3·00	504	562	538	126·00	2485	4. 28
15. 3	1·75	·65	3·50	556	564	591	139·00	2800	3. 29
16. 2	1·50	·50	4·75	665	530	753	166·25	2870	2. 30
17. 1	2·25	·85	4·50	498	560	533	124·50	2240	1. 31
18. 1′	2·25	·75	3·25	513	526	585	128·25	1610	1′. 32
19. 2′	2·25	·85	2·75	419	566	444	104·75	2150	2′. 33
20. 3′	2·50	·75	2·85	421	544	464	105·25	2100	3′. 34
21. 4′	2·25	·65	3·00	460	564	490	115·00	1820	4′. 35
Total	16·75	5·65	27·60	4036	4416	4398	1009·00	18075	—
Aver.	2·093	·706	3·45	504·5	552	549·75	126·125	2259·37	—

E = 650960. S = 1324.

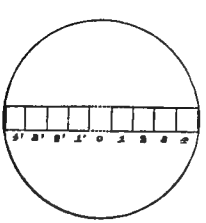

FIG. 31.

These experiments are similar to the last, but the specimens were taken from a larger tree, and the soft wood about the pith, including the heart-shake, was allowed to drop out. In this case the woody layers were placed vertically in the machine for testing them transversely (Fig. 31).

The mean results of the transverse experiments are as follows, viz. :—

The pieces 1 and 1′, s.g.	543,	broke with	505 lbs.	E=622720.	S=1327
,, 2 ,, 2′, ,,	548,	,,	542 ,,	E=752450.	S=1423
,, 3 ,, 3′, ,,	559,	,,	488 ,,	E=976160.	S=1282
,, 4 ,, 4′, ,,	563,	,,	482 ,,	E=612170.	S=1265

And of the tensile:

The pieces	1 and 1′,	s.g.	543,	broke with	1,925 lbs.
,,	2 ,, 2′,	,,	548,	,,	2,510 ,,
,,	3 ,, 3′,	,,	559,	,,	2,450 ,,
,,	4 ,, 4′,	,,	563,	,,	2,152 ,,

We find here that the denser layers are at 4 and 4′, near the outside of the log, but we are not sure as to the amount of wood removed in hewing it, so that it may perhaps compare with the specimens in Table CXLIX. as to position of growth. It will be seen that the point of greatest transverse strength is at or near 3 and 3′, and that of the tensile at or near 2 and 2′.

There is a marked difference in the strength of the wood on the two sides of this tree, since 1, 2, 3, and 4 have a mean transverse strength of 556, and 1′, 2′, 3′, and 4′ of 453 only, the difference being 103, or about 18 per cent. This is further remarkable in the tensile strength, since 1, 2, 3, and 4 have a mean strength of 2599, and 1′, 2′, 3′, and 4′ of 1920 only, the difference being 679, or about 26 per cent.

TABLE CLI.

Tensile Experiments.

Number of the specimen.	Dimensions of the pieces.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
36	2 × 2 × 30	464	7,280	1,820
37		444	7,840	1,960
38		506	9,205	2,301
Total . .	...	1414	24,325	6,081
Average .	...	471	8,108	2,027

TABLE CLII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
39—42	3·625	6·750	15·75	22·875
43, 44	3·000	6·875	—	—
45, 46	2·125	7·250	—	—
47, 48	2·250	8·000	—	—
49, 50	1·875	8·000	—	—
51, 52	2·250	7·750	—	—
Total . .	15·125	44·625	—	—
Average .	2·521	7·437	15·75	22·875
Do. per in.	2·521	1·859	1·75	1·430

Vertical Experiments.—Four pieces, Nos. 53, 54, 55, *and* 56, *each* 2 × 2 *inches, and respectively*

	1	2	3	4	Inches in length.
Crushed with	8·5	7·454	8·25	7·875	Tons.

Contracts are annually made for the supply of Canada Yellow Pine timber, deals, and masts, yards, and bowsprits for the Royal Navy, according to the following specifications and conditions:

The Yellow Pine timber to be of the first quality, 16 inches square and upwards; 20 feet long and upwards, and the spine must be seen from the butt to the top on each of the four sides.

The Yellow Pine deals to be of the first quality, bright, 3 inches thick, not less than 11 inches broad, and 12 feet long and upwards. The whole to be clean and bright in quality.

All the Yellow Pine masts, yards, and bowsprits to be perfectly straight, well and in a workmanlike manner wrought; the masts, yards, and bowsprits not to be hewn into eight squares, but all to be left in the square, similar to mast timber, and to have most of their sap taken out.

The masts, yards, and bowsprits are not to be tapered from their partners downwards, but to be kept as big at the heel as they are at the partners, and in their four squares as aforesaid; nevertheless, it is not expected that no sap shall remain at the edges of the said four squares; but it will be judged sufficient if such masts, yards, and bowsprits are capable of being cleared of sap when brought into their usual squares.

No mast, yard, or bowsprit to have large or sudden bites, or large knots, or any defects that may render them unfit to serve for the use for which they are required.

The diameter and length of the Yellow Pine masts, yards, and bowsprits to be in the following proportion :—

Mast pieces, 25 inches and upwards diameter, the length to be at least three times the diameter considered as feet; and under 25 inches to be three times the diameter considered as feet, with 9 feet added.

i.e. $25 \times 3 = 75$ feet. | $24 \times 3 + 9 = 81$ feet. | $20 \times 3 + 9 = 69$ feet.

Yellow Pine masts.—Heads, or upper part...		$\frac{2}{5}$
Hounds, or lower part...		$\frac{4}{5}$
3rd Quarter		$\frac{8}{9}$
2nd Quarter		$\frac{20}{21}$
1st Quarter		$\frac{40}{41}$
Heel	as partners	

of the partners.

N.B.—Both partners are the bigness of the mast. Length of the head, 4¾ inches to every yard the mast is long; from the heel to the lower partners, one-sixth of the mast; ditto, upper partners, five-eighteenths.

The four quarters are divided between the upper partners and upper part of the hounds.

Yard pieces, the length to be at least 4 feet 3 inches for every inch of diameter in the slings.

i.e. $24 \times 4{\cdot}25 = 102$ feet. | $20 \times 4{\cdot}25 = 85$ feet.

Yards, 1st Quarter		$\frac{40}{41}$
2nd ,, ...		$\frac{9}{10}$
3rd ,, ...		$\frac{3}{4}$
Yard arms		$\frac{1}{2}$

of the slings.

Bowsprit pieces, the length to be 2 feet for every inch of diameter at the bed, with 1 foot added.

i.e. $24 \times 2 + 1 = 49$ feet. | $20 \times 2 + 1 = 41$ feet.

End		$\frac{2}{3}$
3rd Quarter		$\frac{10}{12}$
2nd Quarter		$\frac{10}{11}$
1st Quarter		$\frac{40}{41}$
Heel		$\frac{40}{41}$
For setting off the lengths.		

of the bed.

From the heel to the lower end of the bed, one-seventh of the bowsprit; to the upper end of the bed, three-eighths of the bowsprit.

1. *Quality.*—All the goods to be supplied under this contract to be of the best quality, fresh cut, good, sound, merchantable, and well-conditioned.

CHAPTER XXXV.

PINES—(*Continued*).

THE AMERICAN PITCH PINE TREE (*Pinus rigida*).

THIS tree is found spread over a wide tract of country lying between the Penobscot and the Mississippi rivers in North America. It is of erect and almost perfectly straight growth, and may be readily distinguished from others by its leaves being in threes, by the rigidity and sharp edges of the scales of the cones, by the extreme roughness of its bark, and by the density of the brushes of its stiff and crowded leaves. It requires a good supply of moisture to bring it to the greatest perfection, and flourishes well on a sandy soil if mixed with loam.

The Southern States produce the best spars for masts, square timber, and plank, and these are shipped to this country chiefly from the ports of Savannah, Darien, and Pensacola, in the States of South Carolina, Georgia, and Alabama. The mast-pieces are generally of moderate dimensions, and take the place of Riga or Dantzic spars of 18 to 16 hands, whenever there is any difficulty in procuring either of those descriptions, and except that the Pitch Pine has a greater specific gravity, there is little to prevent it from being used more extensively than hitherto, in lieu of the Baltic Firs.

The timber is usually imported in well-hewn logs of 11 to 18 inches square by from 20 to 45 feet in length,

the planks in thickness varying from 3 to 5 inches by 10 to 15 inches in width, and from 20 to 45 feet in length. Pitch Pine is extensively employed in ship-building for beams, shelf, and bottom planking, &c., &c., and also in civil architecture wherever long, straight, and large scantlings are needed. It will not, however, make good board for joiners' general purposes, although we find it is used to some extent for cabinet work.

The wood is of a reddish-white colour, clean, hard, rigid, highly resinous, regular and straight in the grain, and, compared with most other Pines and Firs, is rather more difficult to work; it is good in quality, and considered to be durable. The principal defects in Pitch Pine are the heart and cup shake, the latter often extending a long way up the tree. Hence, as far as possible, logs having these defects should be used in large scantlings, to guard against a waste of wood near the centre.

TABLE CLIII.—PITCH PINE (AMERICAN).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1	1·25	·15	5·05	1,068	651	984	267·00
2	1·25	·15	3·75	902	630	859	225·50
3	1·00	·00	5·00	1,145	693	991	286·25
4	1·00	·00	4·65	1,005	662	911	251·25
5	1·25	·15	5·15	968	620	937	242·00
6	1·00	·00	5·15	1,207	698	1038	301·75
Total .	6·75	·45	28·75	6,295	3954	5720	1573·75
Average	1·125	·075	4·791	1,049·16	659	953·3	262·29

REMARKS.—All the specimens broke with a short fracture.

E = 859950. S = 2754.

The specimens Nos. 1 to 6 were selected pieces, but not all taken from the same tree.

The following were taken from a continuous strip cut the whole length of the tree.

TABLE CLIV.—PITCH PINE (AMERICAN).

Transverse Experiments.—2nd Example.

(Butt to Top, inner part of the tree. Fig. 32*a*.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
7	1·25	·10	9·75	860	932	554	215·00
8	1·25	·00	5·00	1020	764	801	255·00
9	1·25	·00	4·50	990	682	871	247·50
10	1·35	·00	4·25	874	652	804	218·50
11	1·25	·15	4·50	876	632	833	219·00
12	1·4	·00	3·25	715	586	732	178·75
Total .	7·75	·25	31·25	5335	4248	4595	1333·75
Average	1·291	·0416	5·208	889·16	708	766	222·29

REMARKS.—No. 7 fractured but not broken asunder, highly resinous; Nos. 8, 9, 10, and 11 broke a little short; 12 broke with a long splintery fracture.

$$E = 722360. \qquad S = 2334.$$

Specimens Nos. 7 to 12, with the early layers or growth, were taken at about 3 inches from the pith of a centre plank cut from a log 42 feet in length. (Fig. 32.)

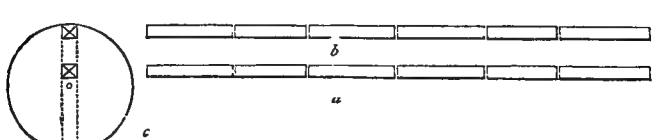

FIG. 32.—*a*, *b*, *c*.

TABLE CLV.—PITCH PINE (AMERICAN).

Transverse Experiments.—3rd Example.

(Butt to top, outer part of the tree. Fig. 32*b*.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
13	1·15	·00	3·75	1,035	840	740	258·75
14	1·15	·15	2·75	985	788	725	221·25
15	1·00	·00	5·00	1,110	760	876	277·50
16	1·25	·15	3·75	920	655	843	230·00
17	1·25	·00	4·75	925	613	905	231·25
18	1·35	·20	4·75	845	610	831	211·25
Total .	7·15	·50	24·75	5,820	4266	4920	1,430
Average	1·191	·0833	4·125	970	711	820	238·33

REMARKS.—No. 13 broke short and split; 14, curl in the grain and broke short; 15 and 16 broke short and split; 17 and 18 broke with short fracture.

$$E = 815070. \qquad S = 2546.$$

Specimens Nos. 13 to 18, with the later layers or growth, were taken from the outside of the same plank, the object being to ascertain in the two sets of experiments—Tables CLIV. and CLV.—in which part of the length the maximum of strength lay. Table CLIV. shows that in the early layers it is in specimen 8, the second piece from the butt-end; and Table CLV. shows that in the wood of later growth it is in specimen 15, the third piece from the butt-end. We also see in the mean results of the experiments that the strength of the inner is to the outer wood as 889 : 970.

Further experiments on the transverse strength of the inner and outer layers of wood of another Pitch Pine tree were then carried out, with the following results:—

TABLE CLVI.—PITCH PINE (AMERICAN).

Transverse Experiments.—4th Example.

(Butt to top, inner part of the tree.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
19	1·25	·00	4·50	760	583	782	190·00
20	1·50	·15	5·00	778	550	849	194·50
21	1·25	·00	3·75	752	531	850	188·00
22	1·50	·25	4·75	705	505	837	176·25
23	1·50	·25	4·75	695	501	832	173·75
24	1·50	·10	4·50	710	498	855	177·50
Total .	8·50	·75	27·25	4400	3168	5005	1100·00
Average	1·416	·125	4·541	733·33	528	834	183·33

REMARKS.—Specimens all broke with fracture of a few inches in length.

E = 701530. S = 1925.

TABLE CLVII.—PITCH PINE (AMERICAN).

Transverse Experiments.—5th Example.

(Butt to top, outer part of the tree.)

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
25	1·50	·10	4·75	805	601	803	201·25
26	1·25	·15	5·00	778	572	816	194·50
27	1·25	·05	4·25	742	533	835	185·50
28	1·50	·15	4·00	725	530	821	181·25
29	1·50	·05	4·00	739	528	839	184·75
30	1·50	·00	3·75	741	518	858	185·25
Total .	8·50	·50	25·75	4530	3282	4972	1132·50
Average	1·416	·083	4·291	755	547	829	188·75

REMARKS.—Specimens all broke with fracture of a few inches in length.

E = 677270. S = 1982.

Specimens 19 to 24, with the early layers, also 25 to 30, with the later layers of wood, were taken from a log of the same dimensions as the last, and under precisely the same conditions as those referred to in Tables CLIV. and CLV., the results being nearly as before; that is, specimen 20, or the second piece from the butt-end of the early growth, and specimen 25, or the butt length of the later growth, are the two strongest pieces of the respective series. We also see in the mean results of the experiments that the strength of the inner is to the outer wood as 733 : 755. Thus the outside is as before, the strongest.

The mean of Tables CLIII. and CLVI., with early layers or inner wood, E = 711945. S = 2130.

The mean of Tables CLV. and CLVII., with later layers or outer wood, E = 763800. S = 2264.

TABLE CLVIII.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the pieces broke with.	Direct cohesion on 1 square inch.
	Inches.		lbs.	lbs.
31	2 × 2 × 30	693	16,800	4,200
32		630	17,640	4,410
33		651	19,320	4,830
34		620	17,920	4,480
35		662	19,600	4,900
36		698	20,720	5,180
Total . .	...	3954	112,000	28,000
Average .	...	659	18,666	4,666

TABLE CLIX.

Vertical or Crushing Strain on cubes of 2 inches.

No. 37.	No. 38.	No. 39.	No. 40.	No. 41.	No. 42.	Total.	Average.	Ditto on 1 square inch.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
10·875	11·125	11·5	11·625	12·00	12·125	69·25	11·542	2·885

CHAPTER XXXVI.

PINES—(*Continued*).

THE OREGON OR DOUGLAS PINE, OR FIR TREE (*Abies Douglasii*).

THIS noble and gigantic species of Pine, or Fir, is, according to Mr. Douglas, to be found in large forests in North-Western America, stretching from 43° to 52° of North latitude. It is an evergreen of erect growth, varying from 100 to fully 200 feet in height, and from 5 to 25 feet in circumference, and occasionally even exceeding this measurement in girth. The bark is rough, and varies from 1 to 2 inches in thickness.

The wood is reddish-white in colour, close, straight, and regular in the grain, tough, elastic, has very little alburnum or sap-wood, and is remarkably free from knots, it being no uncommon thing to find pieces 70 to 80 feet in length without a single one upon the surface. In general appearance it more closely resembles the Red Pine (*Pinus resinosa*) of Canada than either of the other Pines and Firs with which we are acquainted. It is, however, slightly harder than the Red Pine, and less firm in texture.

The Oregon Fir or Pine is rather more rapid in its rate of growth than the Firs and Pines generally are,

and makes about 24 inches in diameter in a hundred years, or, as I have proved by an average of several specimens, it makes 1 inch diameter of wood in 4·32 years.

Cargoes of Oregon Fir spars are occasionally brought to this country, together with a little timber and plank; but it can scarcely be said that there is as yet any regular trade kept up in this wood, owing chiefly to the great cost of transport, the heavy freight charges preventing its importation and successful competition with the Canadian and Baltic Firs, which can be put upon the London market at less expense.

The Oregon spars are generally well dressed, or manufactured for the market, are perfectly straight, and vary from about 10 inches in diameter and 40 feet in length, to 32 inches in diameter and 110 feet in length. They are much sought after, and are well adapted for lower-masts, yards, and bowsprits, &c., &c.; for yachts, and for the royal and mercantile marine. For top-masts, however, where there is often much friction, they are not so well suited as Riga or Dantzic Fir, or the Kauri Pine of New Zealand, owing to the want of cohesion in the annual layers.

A good specimen of the Oregon Fir, 159 feet in length, was placed in the Royal Botanic Gardens at Kew for a flagstaff, about the year 1861, and seems likely to do good service there. One or two such spars, suitable for flagstaffs, the dimensions varying from 9 to 14 inches in diameter, and 80 to 110 feet in length, are commonly brought with each cargo.

The present price (1875) of these Oregon Pine spars for masts, &c., varies from £7 10s. to £11 10s. per load of 50 cubic feet, according to size. This is in excess of that usually charged for the Yellow Pine of Canada, but,

looking to the superior manufacture of the Oregon spars, the actual difference in cost is very small indeed.

For the square timber and planks, which are brought as stowage goods with the spars, no quotations are given, and, in a general way, they must always be ruled by the market price for Canadian and Baltic square Fir timber.

The clean appearance and straightness of the Oregon Fir timber are quite sufficient to recommend it for many purposes in carpentry, and it certainly may be used with advantage in both naval and civil architecture, in lieu of the more well-known Firs. The specific gravity of this wood, when seasoned, is about 605.

CHAPTER XXXVII.

NEW ZEALAND TREES.

THE KAURIE, OR COWDIE PINE (*Dammara Australis*),

Is a native of and is found only in New Zealand. It is most plentiful about the middle part of the northern island, where there are very extensive forests of it, but it is only moderately abundant a little farther south, and towards Wellington, and in the middle island, it is only sparingly met with.

It is a tall and very handsome tree, with a slightly tapering stem, and reaches, in sheltered situations, a height of 100 to 140 feet, with a circumference of from 9 to 15 feet; and even much larger specimens are occasionally met with. At Wangaroa, a little to the northward of the Bay of Islands, I measured one that was 48 feet in circumference at 3 feet from the ground. It was a well-grown, healthy-looking tree, with a heavy cluster of branches thrown out at about 66 feet from the base, and these, spreading obliquely, covered a large space. Many others approximating in dimensions to this magnificent specimen were seen, but the largest that I ever met with was one standing near to Mercury Bay, which measured 80 feet to the branches, and 72 feet in circumference.

The Kauri is a slower-growing tree than most other Firs and Pines; it is slower even than the Pitch Pine of America, and makes only 1 inch of wood diameter in about 6 or 7 years. Thus, the two noble trees to which I have referred were, by computation, respectively about 1,300 and 2,000 years old; they were, however, almost unavailable for any industrial purpose, as it would be impossible to move these excessively large trees if they were cut down.

The Kauri has a dense foliage of tough leathery leaves, resembling in shape those of the Box plant; they vary from ¾ to 1¼ inch in length, are sessile, and the fruit is a cone of a spherical form of about 3 inches in diameter, enclosed in which are the winged seeds. The bark is quite smooth, and about 1 inch in thickness. It is a peculiarity of this species of Pine, that a fluid gum, or resin, of a milk-like character, oozes spontaneously out from every part of the tree, and hardens upon the surface by exposure to the air, immense masses of this opaque gum being often seen on old trees, suspended from the stem at the forked part of the branches.

Some few years since the British Government sent out several expeditions in succession to New Zealand, to procure spars fit for top-masts for line-of-battle ships, and it was while engaged on this special service that I first became acquainted with the properties of the Kauri Pine timber. Since the colonisation of that country, however, the business has been left to private enterprise, and spars, timber, and gum have occasionally formed part of the return cargoes of store and emigrant ships. Much more timber would, no doubt, have been shipped, were it not for the great expense that attends the working of the forests, and the cost of freight for so long a voyage. These two very costly items effectually pre-

clude the Kauri Pine timber from competing with the Fir timber brought to this country from the Baltic, for ordinary building purposes.

Kauri Pine, when used for masts, yards, &c., is unrivalled in excellence, as it not only possesses the requisite dimensions, lightness, elasticity and strength, but is much more durable than any other Pine, and will stand a very large amount of work before it is thoroughly worn out.

All the thriving and healthy trees have from 3 to 5 inches of alburnum or sap-wood very distinctly marked in them, even when fresh cut. The duramen or heart-wood is of a yellowish-white or straw colour, moderately hard for Pine, strong, clean, fine, close, and straight in the grain. It has a very pleasant and agreeable odour when worked, planes up well, and leaves a beautiful silky lustre upon the surface, resembling, in some degree, the plainest Satinwood. It shrinks very little, and stands well after seasoning; further, it takes a good polish. It is, therefore, valuable for conversion into planks and boards, and is very suitable for cabin and other fitments in ships, for joiners' work generally, or for ornamental purposes.

It is also employed for the decks of yachts, as, from the regularity of its grain and the absence of knots, it looks much better than the Dantzic Fir that is commonly used. It wears, besides, more evenly, and does not require the reconciling or planing over, which is frequently found necessary if other woods are worked.

The Kauri Pine is generally sound, and free from the defects common to many other descriptions of timber; it very rarely has more than a slight heart-shake, even in old trees; the star and the cup shake are also rare; it is, therefore, a remarkably solid timber, and may be

considered one of the best woods for working that the carpenter can take in hand.

There are many experiments on the strength of the Kauri Pine, and the first to be noticed are on specimens taken from the butt-end of a log that was fully 60 feet in length and 22 inches square. A plank 2 inches thick having been taken out of the middle, it was cut to produce six pieces of 2 × 2 × 84 inches, four upon one side of the centre or pith and two upon the other (Fig. 33). The centre piece was excluded from the test as being of too weak a nature to bear comparison with the rest of the wood.

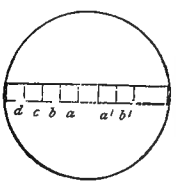

FIG. 33.

TABLE CLX.—KAURI (NEW ZEALAND).

Transverse Experiments.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.				
	Inches.	Inch.	Inches.	lbs.			lbs.
1 *d*	1·25	·00	3·75	818	525	934	131·25
2 *c*	1·25	·15	4·25	875	529	992	132·25
3 *b*	1·15	·10	4·20	820	529	930	132·25
4 *a*	1·05	·00	3·75	750	520	865	130·00
5 *a'*	1·15	·10	3·40	760	515	885	128·75
6 *b'*	1·50	·15	4·15	870	562	929	140·50
Total .	7·35	·50	23·50	4893	3180	5535	795·00
Average	1·225	·083	3·916	815·5	530	917	132·50

REMARKS.—These specimens broke with a moderate length of fracture.

E = 790810. S = 2141.

The table shows that transversely the strongest point was much nearer to the more recently-formed con-

centric circles than to the centre or pith of the tree. Subsequently, from the specimens above-mentioned, I obtained four serviceable pieces, 2 feet 6 inches in length, for the purpose of ascertaining their tensile strength, and found the maximum to lie in the piece marked *c* as before.

TABLE CLXI.

Tensile Experiments.

Number of the specimen.	Dimensions of each piece.	Specific gravity.	Weight the piece broke with.	Direct cohesion on 1 square in.
	Inches.		lbs.	lbs.
7 *d*	2 × 2 × 30	525	16,244	4,061
8 *c*		529	20,440	5,110
9 *b*		529	17,920	4,480
10 *a*		520	18,080	4,520
Total . .	...	2103	72,684	18,171
Average .	...	526	18,171	4,543

TABLE CLXII.

Vertical Experiments on cubes of—

Number of the specimen.	1 Inch.	2 Inches.	3 Inches.	4 Inches.
	Crushed with	Crushed with	Crushed with	Crushed with
	Tons.	Tons.	Tons.	Tons.
11—14	3·125	10·75	24·5	45·75
15—18	3·500	10·00	24·5	48·00
19, 20	3·125	10·50	—	—
21, 22	3·000	10·75	—	—
Total . .	12·75	42·00	49·0	93·75
Average .	3·19	10·50	24·5	46·875
Do. per in.	3·19	2·625	2·722	2·929

Relatively considered, they stand as follows, viz.:—

TRANSVERSE STRENGTH.	TENSILE STRENGTH.
a = ·86	a = ·88
b = ·97	b = ·88
c = 1·00	c = 1·00
d = 93	d = ·78

The specimens referred to in Table CLX., after being prepared for the experiments, lost 9 per cent. of their weight in the twenty days prior to breaking them, and seemed then to be in good-seasoned condition for use.

A further series of experiments were made in a somewhat similar manner to that adopted with the

FIG. 34.

Pitch Pine; but in this case only three lengths were taken from a long Kauri tree—viz., one at the butt, one at the middle, and one at the top end, the intermediate pieces, each about 20 feet in length, being allowed to drop out. Six pieces were, however, taken from the breadth of each plank, three on each side of the pith (Fig. 34).

TABLE CLXIII.—KAURI (NEW ZEALAND).

Transverse Experiments.—Top length.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
23 c'	1·50	·15	3·50	660	534	741	165·0	—	—
24 b'	1·65	·20	3·50	630	560	675	157·5	—	—
25 a'	1·60	·00	2·25	490	580	507	122·5	—	—
26 a	1·40	·00	3·75	690	595	696	172·5	3,412	41
27 b	1·50	·15	4·25	660	540	733	165·0	3,220	42
28 c	1·60	·00	4·75	700	545	771	175·0	2,485	43
Total	9·25	·50	22·0	3830	3354	4123	957·5	—	—
Aver.	1·541	·083	3·666	638·3	559	687	159·58	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

E = 636440. S = 1676.

TABLE CLXIV.

Transverse Experiments.—Mid length.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
29 c'	1·50	·25	4·75	655	498	788	163·75	—	—
30 b'	1·65	·25	4·25	680	528	773	170·00	—	—
31 a'	1·40	·20	5·00	695	553	754	173·75	—	—
32 a	1·25	·15	4·50	740	560	793	185·00	3290	44
33 b	1·35	·15	4·25	680	545	749	170·00	3045	45
34 c	1·35	·25	4·00	705	556	761	176·25	3045	46
Total	8·50	1·25	26·75	4155	3240	4618	1038·75	—	—
Aver.	1·416	·208	4·458	692·5	540	769	173·125	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

E = 735920. S = 1818.

TABLE CLXV.

Transverse Experiments.—Butt length.

Number of the specimen.	Deflections.			Total weight required to break each piece.	Specific gravity.	Weight reduced to specific gravity 600.	Weight required to break 1 square inch.	Tensile Experiments.	
	With the apparatus weighing 390 lbs.	After the weight was removed.	At the crisis of breaking.					Direct cohesion on 1 square in.	Number of the specimen.
	Inches.	Inch.	Inches.	lbs.			lbs.	lbs.	
35 *c'*	1·50	·15	4·00	760	550	829	190·00	—	—
36 *b'*	1·40	·15	3·75	710	580	734	177·50	—	—
37 *a'*	1·50	·20	4·00	705	560	755	176·25	—	—
38 *a*	1·25	·00	3·75	765	595	771	191·25	3325	47
39 *b*	1·25	·15	3·00	640	580	662	160·00	3080	48
40 *c*	1·35	·10	5·25	810	555	876	202·50	3920	49
Total	8·25	·75	23·75	4390	3420	4627	1097·50	—	—
Aver.	1·375	·125	3·958	731·66	570	771	182·91	—	—

REMARKS.—These specimens broke with a moderate length of fracture.

E = 722360. S = 1922.

The mean of the whole being E = 698240. S = 1805.

Relatively considered, these experiments stand as follows :—

TRANSVERSE STRENGTH.

Top-length.

$a - a' = ·87$
$b - b' = ·95$
$c - c' = 1·00$

Mid-length.

$a - a' = 1·00$
$b - b' = ·95$
$c - c' = ·95$

Butt-length.

$a - a' = ·94$
$b - b' = ·86$
$c - c' = 1·00$

TENSILE STRENGTH.

Top-length.

$a - a' = 1·00$
$b - b' = ·94$
$c - c' = ·73$

Mid-length.

$a - a' = 1·00$
$b - b' = ·93$
$c - c' = ·93$

Butt-length.

$a - a' = ·85$
$b - b' = ·79$
$c - c' = 1·00$

and of the above the relative strength of the series are—

$a - a' = \cdot 952$	$a \quad a' = 1 \cdot 000$
$b - b' = \cdot 932$	$b - b' = \cdot 937$
$c \quad c' = 1 \cdot 000$	$c - c' = \cdot 937$

We find, also, the relative transverse strength of the three lengths is as follows, viz. :—

Top-length = ·870
Mid ,, = ·947
Butt ,, = 1·000

and the specific gravity—

Top-length = ·980
Mid ,, = ·946
Butt ,, = 1·000

The tables show that the maximum transverse strength lay in the outer series marked $c' - c$. It is not, however, certain whether the tree from which they were taken, although reduced to 22 inches square, would not have yielded a much larger square log, say 28 or 30 inches; and thus it seems probable that the point c, although nearer to the outside of this log than in the other, may, after all, be in about the same position in the tree. The experiments for the tensile strength show that the series $a' - a$ were the strongest.

Table CLXII. shows that the vertical strength of Kauri timber is about 2·8665 tons per square inch of base.

CHAPTER XXXVIII.

NEW ZEALAND TREES—(*Continued*).

THE KAHIKATEA OR KAKATERRA TREE (*Dacrydium excelsium* or *Dacrydium taxifolium*).

THIS majestic and noble-looking tree belongs to the natural order of *Taxaceæ*, more commonly known by the name of Joint Firs. It is a native chiefly of the temperate zone, and found abundantly in the close and dense forests of New Zealand, occupying many of the deep ravines, and generally preferring shelter and a low-lying moist situation to bring it to the greatest perfection.

It is of straight and lofty growth, frequently attaining a height of 150 to 180 feet, with a circumference of 6 to 15 feet. It is not an uncommon thing to meet with trees of this description, rising 60 feet and upwards in the stem, without a branch, and from thence to see them spreading out obliquely and forming a splendid conical top. The bark is dark brown in colour, rough, in strips, and also scaly; the lower portion of the stem being generally covered with moss.

The leaves are short, dark-green in colour, narrow, rigid and erect, bristling evenly all round the branchlets. The fruit is a red berry, which the natives are very fond

of; and it is said that a beverage, resembling in its anti-scorbutic qualities the well-known spruce beer, may be manufactured from the branches.* These trees are generally overrun with strong elastic creepers, of from 4 to 6 inches in diameter, which intertwine with the branches, and, clustering there, render the whole a grand and densely thick mass of rich foliage.

The Kahikatea yields timber 12 to 30 inches square, and 20 to 60 feet in length. The wood is white in colour, light, straight in the grain, soft, and with little of the horny texture observable in the outer part of the concentric circles of the Fir and Pine species. It resembles the *Pinus Strobus*, or Yellow Pine of Canada, more closely, perhaps, than any other wood. It is easy to work, but is inferior in quality, being neither strong nor durable.

The natives of New Zealand sometimes make their canoes from this wood, as it is easily obtained. It does not, however, wear well, and, except for its buoyancy and handiness upon the streams, has little to recommend it to notice. It is not employed in buildings if other timber can be readily procured. The Kahikatea is liable to be speedily attacked by a small worm. I found this to be the case with some specimens, after being only about six months in store.

The Kahikatea has sometimes been mistaken for the Kauri, it being similar in dimensions; when hewn, however, the quality is immediately seen to be inferior, and quite unfit for mast purposes. The specific gravity of the seasoned wood varies from 428 to 490, and averages about 460.

* Lindley's "Vegetable Kingdom."

THE TANAKAHA TREE (*Podocarpus asplenifolius*) is found scattered over a large portion of the northern island of New Zealand, but is nowhere met with in abundance. It arrives at its greatest perfection on a dry soil and at a moderate elevation.

It is of straight growth, and attains a height of 60 to 80 feet, with a circumference of about 5 feet, the branches being thrown out nearly horizontally at about 30 to 40 feet up the stem, and forming above this a fine pyramidical head. The leaves are 1 to 1½ inch in length, and ½ to ¾ inch in breadth. The bark is thick, smooth, and of a dark-brown colour: it is used by the natives to dye their garments either black or brown.

The wood is close and straight in the grain, and yellowish-white in colour, though not so light as that of the Kauri. It has a close resemblance to the Huon Pine of Van Diemen's Land. It works up well, is tough and very strong; so much so that the New Zealanders say it is the "strong man" among their forest trees.

The Tanakaha tree yields timber 10 to 16 inches square, and 18 to 45 feet in length, and is employed for masts, and for the decks of small vessels built for the coasting trade; it is found to answer admirably for these purposes, and is also valuable to the carpenter as a building material.

The specific gravity of the seasoned wood is about 600, but logs which have been only felled a few weeks, and therefore have their moisture only partially evaporated, will not float.

THE RIMU TREE (*Dacrydium cupressinum*).

This tree is found in many of the forests of New

Zealand, and is one of the most magnificent of the vegetable productions of that country. It is tolerably abundant, prefers a rich alluvial soil, moisture and shelter, and is rarely seen upon dry or moderately elevated situations.

It is of straight growth, and attains a height of from 80 to 100 feet, with a circumference of 6 to 9 feet. It rises fully 40 to 50 feet clear of branches, above which they are thrown out in long, curved, pendulous forms. These, in their turn, give out numerous filamentary branchlets, surrounded with short, light green, thread-like leaves, the whole drooping, and exhibiting a very graceful appearance, and rendering the tree especially valuable for ornamental purposes.

The duramen, or heart-wood, is much varied in colour; for some few inches round the pith it is brown or chestnut, but beyond this it is lighter, with a nice diversity of shade and figure. It is moderately hard, but appears to be deficient in tenacity, it planes up smoothly, takes a good polish, and would be useful to the cabinet-maker for the manufacture of furniture.

The Rimu tree yields timber 10 to 30 inches square, and 20 to 50 feet in length; the natives employ it for their buildings and stockades, and occasionally for making canoes, but they swim rather heavily as compared with Kauri; they wear well, however, and last them a long time.

Several of these beautiful Rimu plants, which I brought to England in the years 1841 to 1843, Sir Wm. Symonds presented to the Royal Botanic Society for their Gardens at Kew, where, under the careful management of Sir Wm. Hooker, they grew up to be fine trees of 25 to 30 feet in height. They stood for many years, during the summer months, in large square

cases or tubs in the open, and were greatly admired by the visitors, but, in the winter time, they were removed under shelter.

The specific gravity of the Rimu, when seasoned, is about 678.

THE MIRO TREE (*Podocarpus ferruginea*)

is found in slightly elevated situations in many of the forests of New Zealand; it prefers shelter and a damp, although not an excessively moist soil, to bring it to perfection. It is of straight growth, and reaches the height of about 60 feet, with a circumference of 5 feet. The stem is clean, and rises to 30 or 35 feet clear of branches, above which they are thrown out nearly horizontally. The foliage is dark-green, very thick, and the leaves are about ⅛th of an inch in width, and 1 inch in length; the fruit is a red berry with a hard stone; it is a favourite food of the wood-pigeon.

The wood varies from light to dark-brown in colour, is close in grain, moderately hard and heavy, planes up well, and takes a good polish. Some logs are nicely figured; it is, therefore, very suitable for cabinet-makers' work, &c. It would also be useful to the turner, and for any ornamental work, and as it yields timber 10 to 18 inches square, and 20 to 30 feet in length, it would, no doubt, be fit for civil architecture.

The specific gravity of Miro in a green state is 1214, but, when seasoned, varies from 660 to 752.

THE TOTARA TREE (*Taxus*, or *Podocarpus totara*)

is of erect and straight growth, and attains the height of about 80 to 90 feet, with a circumference of 6 feet. It is tolerably abundant, and is found in many of the forests

of the northern island of New Zealand. It is often met with upon the banks of rivers, where the tide washes its roots; but, generally, it seems to require shelter and a moderately moist soil to produce the finest trees.

It rises with a clean stem to about 35 to 40 feet, above which the branches are thrown out horizontally. The foliage consists of sharp-pointed dark green leaves, of about 1¼ inch in length by ¼ inch in width; they are thick, rigid, and prickly to the touch. The bark is red in colour, and ringed at about 1 foot apart; the outer layers hang in thin long flakes; strips of this bark are often used as a thatch for roofing.

The Totara tree yields timber 10 to 22 inches square, and 20 to 45 feet in length. The wood is red in colour, close, straight, fine and even in grain, and is moderately hard and strong. It works up exceedingly well, and, although plain in appearance, would be found a good substitute for Mahogany, whether used for furniture, carpentry, or in the domestic arts. It might also be employed with advantage in civil architecture. The alburnum or sap-wood is generally from 2 to 3 inches thick on this description of timber, and is lighter in colour than the duramen or heart-wood.

The natives make their small and medium sized canoes of the Totara, and generally prefer that the rising strake of the larger ones, and especially those employed in war, should be of this wood, as it wears better than Kauri, and is considered durable. I gathered the information from several intelligent natives that in the southern districts there are very large forests of Totara trees, of sufficient size and length for masts of ships of 1,000 to 1,500 tons burthen.

When fresh cut the specific gravity of this wood is about 1230, but when seasoned it is only about 600.

THE RATA TREE (*Metrosideros robusta*).

This magnificent tree is found in the denser forests of New Zealand, where it reaches its greatest perfection on a rich soil, and with a moderate degree of moisture. In such situations it very commonly attains the height of 80 to 100 feet, with a circumference of from 9 to 12 feet.

It often rises with a clear stem to 30 and even 40 feet without a branch, and then puts out very ponderous and robust arms, forming a heavy top. The leaves are marginate, and of a light-green colour, 1½ inch in length and ½ inch in width. In December and January this tree puts forth very beautiful crimson polyandrous flowers, which render it conspicuous at a considerable distance.*

The Rata tree yields timber 12 to 30 inches square, and 20 to 50 feet in length. The bark is ragged in appearance and dark-brown in colour; the wood red, hard, heavy, close-grained, strong, and not difficult to work. It is fit for employment in ship-building, and for any work in civil architecture requiring timber of straight growth and large dimensions; the natives assert that it is very durable.

The specific gravity of the Rata, freshly cut, is about 1228, but when seasoned only about 786.

THE POHUTUKAWA TREE (*Metrosideros tomentosa*)

is found only on the rocky shores and outlets of rivers

* There are some very fine creepers growing up the stem and over the tops of the tallest trees in the New Zealand forests, that are so exceedingly like the Rata in wood, bark, leaf, and flower, that I could never distinguish any difference between them. The natives say, with reference to the Rata tree, that in some districts it sends down tendrils from its branches, which take root in the ground, and assume in time the form and solidity of stems.

in New Zealand. It prefers an exposed situation to any other, and requires but little soil for its nourishment.

The bark is ragged in appearance, thick, reddish-grey in colour, and yields a good brown dye. The tree is very hardy, attains moderate dimensions, is crooked, misshapen, and branchy, with not more than 10 to 18 feet in length of clear stem. It has a thick foliage of dark green glossy leaves of about 1½ inch in width by 2 inches in length, and in December puts forth quite a covering of large crimson polyandrous flowers.

The Pohutukawa tree yields timber 9 to 16 inches square, and 10 to 20 feet in length. The wood is red in colour, hard, strong, heavy, and close-grained. In form and quality it is admirably well adapted for the frames of ships, or any other purpose where curved timber is required. The natives speak of it as being very durable.

Specimen logs of this compass timber were brought to England in 1843, and placed in store at Chatham Dockyard, for use experimentally in ship-building, and in 1869—*i.e.*, twenty-six years later—two or three pieces were still there in a perfectly sound state. The specific gravity of Pohutukawa, green or fresh cut, is about 1200, but after seasoning it is only about 858.

THE PURIRI TREE (*Vitex littoralis*)

is common to nearly all the forests of New Zealand, and flourishes in almost any situation, but the best trees are those grown on a rich soil, and sheltered from strong winds.

The stems of these trees vary from straight to every imaginable form of curved growth, and are seldom seen standing erect. Usually they have a short clear bole or

trunk of from 8 to 18 feet in length, with a circumference of 6 to 9 feet, and an overpowering weight of robust branches. The foliage is a deeply-veined, plain-edged, light-green leaf, 2 inches in breadth by 3 inches in length. It flowers nearly all the year round, and is especially full in September; the flowers are of a deep red colour, and somewhat bell-shaped. The fruit, which is like a cherry, is a favourite food of the wood-pigeon.

The Puriri tree yields timber 9 to 18 feet in length, and 10 to 18 inches square. The bark is thin, smooth, and greyish-white in colour. The wood is dark brown, extremely hard, heavy, close-grained, and generally free from defects, the exception being that it is liable to some slight injury during growth from a worm, which bores it from the roots upwards, leaving a clean hole of from ½ to ⅝ths of an inch diameter. The alburnum or sap-wood on this tree is generally from 2 to 3 inches thick, and of a yellowish colour.

This timber is very durable, and suitable for the frames of ships, and also for many other purposes where hard, short, curved wood is required. Specimen logs were brought to England to be used experimentally in ship-building. The specific gravity of Puriri in a green state is about 1100, and when seasoned it is nearly 1000.

The Kauri, Kahikatea, Tanakaha, Rimu, Miro, Totara, Rata, Pohutukawa, and Puriri trees are the principal, and, except the Kahikatea, probably the most valuable of all that can be found in New Zealand. Still there are many other varieties, about thirty, some ten or twelve of which could be made available for building and cabinet purposes; the remainder would be more or less useful for the manufacture of agricultural implements, fuel, &c., &c.

Subjoined is a list of the New Zealand trees met with, in addition to the nine just described.

10. Rewarewa.
11. Kahikatoa.*
12. Tawa.
13. Karoa.
14. Toraira.
15. Tongiho.
16. Pugatea.
17. Wawaku.
18. Hinau.
19. Kowai.
20. Kohehu.
21. Ramarama.
22. Pukapuka.
23. Mohoi.
24. Aki.
25. Akipero.
26. Towai.
27. Kohekohe.
28. Matai.
29. Karaka.
30. Tepow.
31. Tee.
32. Mida.
33. Tarata.
34. Kohutuhutu.
35. Nana.
36. Oroaka.
37. Kiwideah.
38. Tototo.
39. Manawa.
40. Tawada.

* The Kahikatoa tree is of moderate dimensions, and yields a hard red wood; it differs widely from the Kahikatea tree described at page 305.

CHAPTER XXXIX.

ON THE SEASONING AND PRESERVATION OF TIMBER.

THE properties and characteristic qualities of the various species of timber being known, it will be easy for any one engaged in engineering or architectural works to select the particular species or kind most suited for his purpose; he will also, by the aid of the tables of experiments upon the several varieties, be enabled to determine the scantlings, and thus economise the process of conversion.

It has been stated in Chapter XI., from observations extending over many years, that Oak and other timber felled during the winter was preferable for constructive purposes to that felled in the spring or summer months; but this must be taken only as applying to the deciduous trees, there not being, so far as I am aware, any difference in the wood of the evergreens whether they are felled in the winter or the spring months. As regards the former class, however, I have carefully examined and compared a great many pieces of both winter and spring or summer felled logs, and found, almost invariably, that the winter-cut timber, after being a few years in store, was in better condition than that which had been cut in the spring. Both, be it observed, having been under similar treatment for preservation.

The winter-felled logs were sounder, less rent by shakes, and the centres or early growth generally showed less of incipient decay than the spring-felled. The centres in both, however, unless they are carefully protected from the weather, are liable to be deteriorated at the ends after being about three years in store, and if exposed for a longer period, the deterioration will be more serious, inasmuch as the shakes will be deeper and more open, and instead of the early stage of decomposition at the ends, there may be decided rot supervening, and involving great waste whenever it is required to be brought into use. The Tewart of Australia and the Greenheart of Demerara are, however, notable exceptions to this, for on these two woods time and weather have little effect; they seem to be almost imperishable.

Ten to twelve years seems but a short time compared with the usual and common duration of timber, and when we hear of the timber framework and fitments of old buildings being found in a sound state after having stood the test of ages, I think it should be understood that it could only have been under certain very favourable conditions.

First. That the timber was of good quality when selected for employment.

Secondly. That it was at least moderately seasoned when brought into use.

Thirdly. That it was placed in a favourable position in the building for lasting, and where it had a free circulation of air about it, without being in a draught.

Fourthly. That the temperature was moderate and regular, and not subject to sudden calorific changes, or even to too strong a light.

The most effectual way to preserve good timber is to partially season it in as natural a way as possible before

working it up, and to give it simply that protection when brought into use which all other materials require to keep them from perishing. It need not be too soon varnished, painted, or coated with any preservative compound whatever, but be allowed to undergo after conversion a further short process of the natural seasoning before this is done. Its durability will be thus insured much more effectually than if desiccating, charring, or some other hastening process of seasoning had been resorted to, for the sake of bringing it into earlier use after being felled.

My experience of the approximate time required for seasoning timber under cover, and protected from wind and weather, is as follows :—

Pieces 24 ins. and upwards square,						Oak, require about		26	mths.	Fir,	13	mths.
Under 24 ins.	to	20	ins.	,,	,,	,,	22	,,	,,	11	,,	
,, 20	,,	16	,,	,,	,,	,,	18	,,	,,	9	,,	
,, 16	,,	12	,,	,,	,,	,,	14	,,	,,	7	,,	
,, 12	,,	8	,,	,,	,,	,,	10	,,	,,	5	,,	
,, 8	,,	4	,,	,,	,,	,,	6	,,	,,	3	,,	

Planks from one-half to two-thirds the above time, according to the thickness.

If kept longer than the periods named, the thin fine shakes which first open upon the surface during the process of seasoning will open deeper and wider, until they possibly render the logs unfit for conversion. If, however, the logs be reduced to the scantlings required after partial seasoning, and then further allowed to dry, they will not be liable to tear open so much, but by shrinking gradually will retain a more solid form, and be less objectionable to the eye when placed in position.

The table showing the time necessary for seasoning the various scantlings must be qualified by the consideration that in the case of any foreign timber that will float, the foresters and raftsmen, while transporting it to

the port of shipment, often, and quite unintentionally, do good service in giving it some weeks, if not months, of water seasoning, which should be estimated for in determining its fitness for use, whether it be as a substitute for Oak or otherwise.

Square Fir timber, and rough spars for masts, are often kept too long afloat after they are purchased, under the impression that they will soon be wanted, and therefore their temporary submergence is hardly worth while. Yet, perhaps, from some cause or other, they are not brought so quickly into use as was expected, and months, even years, may pass by without much thought being given to them. The consequence is that just about the line of flotation, and that part which the water washes, the logs are often found to be seriously deteriorated. To insure the preservation of this wood it will therefore be necessary to submerge it without delay.

In cases where it is not convenient to submerge the timber at once, it would do some good if the logs were occasionally turned over. It is a little difficult, however, to accomplish after one-half the log is soddened with water, as then it can only be managed if secured in rafts, and it is almost impossible to permanently change the position of a log, if it be crooked, from that which it naturally takes by its own gravity in the water.

To aid the natural seasoning, and bring about at the earliest possible time the evaporation of the moisture which is contained in all newly-felled timber, the trees should not be allowed to remain long upon the ground where they grew, as the soil is generally damp and wet. They should rather be carried off as early as convenient to the timber yard, and stored there for preservation.

One of the earliest causes of decay may be accounted for by the way in which valuable logs of timber are too

often left to sink by their own weight into soft earth, where they absorb a large amount of moisture. All logs, therefore, as they are brought in, unless stacked at once, should be blocked or skidded off the ground, as a temporary measure; it involves little trouble, and will amply repay the cost of labour.

In stacking timber the following suggestions may be useful:—

First. Let the skidding as a rule be placed as nearly as possible level both ways, and in no case allow the upper side of it to be less than 12 inches distant from the ground; it will then necessarily follow that, whether the stacking ground be level or upon the hill-side, there will be ample space for ventilation under the timber to be piled thereon.

Secondly. Let the butt-ends of the logs be placed to the front, and keep the back or top ends of each tier slightly higher than the butts, for facility in withdrawing them from the stack.

Thirdly. Let the skidding over each tier of logs be level, and place short blocks under it, as packing pieces 1½ or 2 inches in thickness upon every log; the advantage of this is, that by removing the packing pieces any log in the tier, between the two layers of skidding, may be withdrawn from the stack without disturbing the remainder.

Fourthly. If the timber to be stored cannot be placed in a permanent shed, it should, with the view to its preservation, have a temporary roof placed over it. The size of the stack should therefore be considered in setting it out, limiting the breadth or span to about 25 or 30 feet.

Fifthly. Let each tier as it rises be set back 6 to 8 inches, to enable the converter to get over it without a

ladder; he will find it convenient for examining and selecting his logs for conversion.

These rules were carefully carried out at Woolwich Dockyard, where for some few years previous to its being closed, an immense quantity of timber was kept. The stacks, besides being covered in, had the sides and one end also screened from the weather; all this was done with the coarsest description of board in store, and such as could not have been used for joiners' general purposes. The boards forming the screen at the sides were slipped into a groove at top and bottom, and a rail or fillet midway up and outside was secured to the inner framework of the shed by nails driven between the edges of the boards. No other fastening was required, and the advantage of the plan was this—it allowed sufficient play for the boards to shrink or expand according to the weather and the season, while they were still removable at pleasure for any other purpose.

The end or working face of the stack was similarly closed up, but in this case, the boards being more frequently shifted, they were, for convenience, clamped together in twos and threes, and secured with a shifting bar half way up. The timber was thus well protected from the weather, and well ventilated, though not subjected to a draught; and, in 1869, Woolwich yard contained probably the finest and best-preserved stock of timber in England.

It will be seen, then, that the preservation of timber may be cheaply and economically effected, and its seasoning brought about in a steady and regular manner by the adoption of the simplest precautions. Experience has shown that this is the only certain method of insuring its durability, and it is therefore fit that the best attention should be paid to it.

Sheds of a cool, dry, lofty, and permanent character are required for the proper seasoning of thick-stuff, planks, and deals; and it is desirable that the stacks of each of these should be of a moderate breadth only, a passage through the middle of the shed being necessary for the convenience of examining and working each parcel. The ground skidding should be like that of the timber stacks, placed level, and be at least a foot in depth, to admit of a free circulation of air throughout; upon these the planks, &c., should be laid flat, and open at the edges. Each tier should, as it rises, be blocked with dry battens ¾ to 1 inch in thickness, by at least 3 inches in breadth for deals; and 1 to 3 inches thick by at least 4 inches in breadth for plank, &c. These should be placed immediately over the ground skidding, as by so doing it will prevent buckling or warping, and keep the planks straight and fair looking; and further, care should be taken not to stack too high, lest the upper tiers should feel the effects of the sun's heat through the roof.

Boards may either be placed on end and blocked from each other by pegs or battens, or be placed upon racks fitted horizontally to receive them for seasoning. The former plan is in much favour in many places, and especially so in small private yards, where they usually stand in the open. I much prefer, however, a dry, cool shed, fitted with horizontal beams and vertical iron bars, to prevent the boards which are placed on edge from tilting over, and believe that the wood shrinks gradually, more evenly, and is less damaged by splits or shakes than by any other method. Boards season surprisingly well in this way, and when it is considered with what ease and facility they are worked in and out of the frame, there is, I think, much to recommend the plan to favourable notice.

Duhamel considered that by setting timber upright it would season quicker, if not better, than if it were placed horizontally; it is, however, very difficult to do if dealing with large quantities, and is seldom practised. I rather doubt the efficacy of the plan. Fincham did not go quite so far, but experimented on timber placed upon frames set at an angle of about 30°, and it was found that it afforded no good results. The butt-ends dried far too quickly to allow the sap juices, which drained to the lower part, to evaporate; as a consequence, decay was rather accelerated than otherwise.

Steaming or boiling unseasoned timber will fit it quickly for employment in architectural work, but it should only be resorted to in case of necessity, as it takes from its strength, and adds nothing to its durability.

Seasoning in chambers heated to a high temperature is practised to some extent on thin planks, boards, and other small and light material, but it cannot be carried out on timber of large scantlings, owing to the great weight and the difficulty there is in handling it; besides, the storage room required for any considerable quantity of it would be so enormous that it may be looked upon as next to impracticable. Very great care is necessary in drying boards by this desiccating process, the ends need always to be clamped to prevent them from splitting and warping, and they must be firmly secured by thin laths being placed between them. Ordinarily wood thus dried loses in strength, and in coloured woods there is this further drawback, that they generally pale and lose their lustre.

A patent was taken out in France about the year 1861, by M. de Lapparent, Director of the French Dockyards and Inspector of Timber for Naval Purposes, for

carbonising timber by means of inflammable gas (either pure hydrogen, or, better still, lighting gas) directed by means of a tube against every part to be carbonised, just as one would direct a jet of water from a fire-engine upon the flame to be extinguished. A trial of it was made at Cherbourg in presence of the Director of Naval Works and numerous other witnesses, and it is said this was crowned with complete success. The absence of all danger from fire was clearly proved, and this of course removed the principal objection to its introduction in the dockyards. The cost, it appeared from calculations made at the gas-meter of the town, with the aid of an accountant, did not exceed one penny per square metre for gas and labour together.

M. de Lapparent holds that, the surface being once thoroughly dried, the juices of the interior will remain inactive, and the durability of the timber be thereby insured.

I experimented with this process at Woolwich in 1862, by charring seven out of twelve pieces of winter-felled British Oak, prepared to a scantling of 2″ × 2″ × 84″ and disposed of them as follows: for instance, Nos. 3, 7, 8, 9, 10, 11, and 12 were carbonised, and Nos. 1, 2, 4, 5, and 6 were not carbonised. Of the former, Nos. 3 and 10, and of the latter, Nos. 1 and 2, were suspended in a dry place in the store room; Nos. 7, 8, and 9, and Nos. 4, 5, and 6, were put into a box of manure; Nos. 11 and 12 were driven half their length into damp earth, on the stacking ground.

I examined these specimens in 1863 and 1864, and they all appeared to be as strong and sound as when first prepared; they were therefore returned to their places. I again examined them in 1867, and then tested them for transverse strength. The results are given in the following tables:—

TABLE CLXVI.—CARBONISED BRITISH OAK.

Number of the specimen.	Deflections.		Total weight required to break each piece.	Specific gravity.	Weight required to break 1 square inch.	
	With the apparatus weighing 390 lbs.	At the crisis of breaking.				
	Inches.	Inches.	lbs.		lbs.	
3	2·45	4·45	660	626	165·00	Kept dry in the store-room.
10	2·55	4·55	690	622	172·50	
Total .	5·00	9·00	1,350	1248	337·50	
Average	2·50	4·50	675	624	168·75	
7	3·00	4·25	345	1036	86·25	Kept in a box of manure.
8	3·50	5·00	490	1095	122·56	
9	3·25	5·75	530	1080	132·50	
Total .	9·75	15·00	1,365	3211	341·25	
Average	3·25	5·00	455	1070	113·75	
11	—	—	—	—	—	
12	2·75	4·50	480	946	120·00	

REMARKS.—No. 3 broke with scarph-like fracture, 5 inches in length; 10 broke in three pieces, each with scarph of 6 inches; 7 broke with long splintery fracture; 8 broke with splinters, 12 inches in length; 9 broke with splinters, 9 inches in length; 11, lost; 12 broke off short in three pieces.

TABLE CLXVII.—NON-CARBONISED BRITISH OAK.

Number of the specimen.	Deflections.		Total weight required to break each piece.	Specific gravity.	Weight required to break 1 square inch.	
	With the apparatus weighing 390 lbs.	At the crisis of breaking.				
	Inches.	Inches.	lbs.		lbs.	
1	2·00	3·75	700	643	175·00	Kept dry in the store-room.
2	2·50	5·00	770	650	192·50	
Total .	4·50	8·75	1470	1293	367·50	
Average	2·25	4·375	735	646·5	183·75	
4	2·75	4·15	485	1064	121·25	Kept in a box of manure.
5	3·50	4·50	420	1085	105·00	
6	3·50	4·35	440	1090	110·00	
Total .	9·75	13·00	1345	3239	336·25	
Average	3·25	4·33	448·33	1079·66	112·08	

REMARKS.—No. 1 broke with scarph-like fracture, 7 inches in length; 2 broke in three pieces, each scarph-like, 7 inches in length; 4 broke with scarph-like fracture, 14 inches in length; 5 broke rather short, with small splinters; 6 broke with scarph-like fracture, 8 inches in length.

All the specimens that were kept dry, whether carbonised or not, were apparently in good condition; but those which had been placed in manure or damp earth, were more or less in a state of decomposition, the softer parts of the concentric layers being slightly wasted away with rot on the surface. The difference in strength between the carbonised and non-carbonised pieces was not very great, but the tables show that of the pieces kept dry, the loss of strength was greatest by about 8 per cent. in the carbonised specimens; and of those kept in manure, the loss was about 1½ per cent. in excess on the non-carbonised pieces. When the experiment for testing the strength was completed,

the broken pieces of Nos. 4, 5, 6, 7, 8, and 9 were again placed in the box of manure.

The weight of the specimens, taken on five occasions in nine years, was as follows :—

TABLE CLXVIII.

Number of the specimen.	December, 1862.	June, 1863.	September, 1867.	July, 1869.	April, 1871.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
1	12 3	7 13¼	7 13	—	—
2	12 6½	8 0½	7 15	—	—
3	12 2	7 11¼	7 9¾	—	—
4	12 9½	13 1¾	12 15	9 2	7 2
5	12 2½	12 10¾	13 5	10 12	7 8½
6	12 8	12 7¼	13 3	11 2	8 0¾
7	12 8	12 12¼	12 9½	10 14	7 3¼
8	12 12	12 9¼	13 5½	11 6	7 12
9	12 6	12 9½	13 2	9 12	7 5
10	12 3½	7 10¼	7 9	—	—
11	12 8¾	—	—	—	—
12	12 13¾	—	11 8	—	—

Nos. 11 and 12 were left in the ground in 1863, but No. 11 was missing in 1867. Nos. 1, 2, 3, 10, and 12 were lost at the closing of the dockyard in 1869, but the broken pieces in the box of manure were safe, and these I kept until the yard was completely cleared of all its stores in 1871. At that time their condition was as follows :—

No. 4. Both pieces were considerably wasted.

No. 5. One piece much wasted, the other less so.

No. 6. Neither piece much wasted.

No. 7. Both pieces much wasted.

No. 8. On one piece some carbon remained; the other was much wasted.

No. 9. Ditto ditto.

The decay and waste between July, 1869, and April, 1871, was very rapid, but the condition of the carbonised and non-carbonised specimens was much the same; it leaves, therefore, little to say in favour of the charring process, and I should not myself be inclined to use it on timber for works of construction, except as a possible means of preventing the generation of moisture or fungus where two unseasoned pieces of wood are placed in juxtaposition.

An experiment in carbonising was tried on a piece of plank 5 feet in length, one-half the breadth being charred, the other not; this was set in the ground under the drip of a roof. In another case a piece of plank was charred over half its length, the other not. Plates of iron were then secured to each end, and the whole immersed in water to ascertain whether the carbonising of the surface would prevent oxidation. When, however, each of these were examined, some six months later, it could not be seen on which side to give the preference.

The wood backing to the armour plates on the starboard side of H.M.S. "Caledonia" was charred by M. de Lapparent's process, with the view to test its efficacy thoroughly, and when this ship comes under repair it will be ascertained by comparison with the other side how far it is useful in preventing decay. The Admiralty also ordered the faying surfaces of the frame timber and planking of the "Tenedos" and "Spartan," the former building at Devonport, and the latter at Deptford Dockyard in 1868, to be carbonised by this process, in the hope that it will retard the formation of fungus on the surfaces, on which it frequently forms with rapidity; but, as neither of these ships have yet been opened for repairs (1875), it is uncertain whether any good results have come of the experiment.

TABLE CLXIX.

Showing the woods which have been experimented upon, alphabetically arranged—their specific gravity, transverse, tensile, and vertical strength—abstracted from the tables accompanying the description of the various kinds.

Number.	Name of Wood.	Specific gravity.	Breaking Weights used for—					
			Transverse strain on pieces 2″×2″×84″	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces—			
					1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs. per sq. in.	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
1	African	993	277	7,052	4·900	4·573	4·388	4·000
2	Ash, English	736	216	3,780	…	3·109	—	—
3	,, American	480	160	5,495	…	2·453	—	—
4	Blue Gum, Australia	1029	178	6,048	…	3·078	—	—
5	Cedar, Cuba	439	140	2,870	…	2·000	—	—
6	Chow, Borneo	1116	244	7,199	…	5·621	—	—
7	Elm, English	558	98	5,460	…	2·583	—	—
8	,, Canada	748	230	9,182	3·312	4·062	4·097	3·859
9	Fir, Dantzic	582	219	3,231	3·146	3·172	3·097	2·992
10	,, Riga	541	150	4,051	3·312	2·109	1·770	2·179
11	,, Spruce, Canada	484	168	3,934	…	2·166	—	—
12	Greenheart, Demerara	1149	333	8,820	6·750	6·819	6·368	5·814
13	Hornbeam, English	…	…	6,405	…	3·711	—	—
14	Iron-bark, Australia	1142	352	8,377	…	4·601	—	—
15	Jarrah, ,,	1010	172	2,940	…	3·198	—	—
16	Kapor, Borneo	956	296	6,790	…	5·330	—	—
17	Kari, Australia	981	216	7,070	…	…	…	5·140*

* 6 × 6 × 6.

TABLE CLXIX.—(*Continued.*)

Number.	Name of Wood.	Specific gravity.	Breaking Weights used for—					
			Transverse strain on pieces 2″×2″×84″	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces—			
					1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs. per sq. in.*	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
	Kauri, New Zealand	530	204	4,543	3·190	2·625	2·722	2·929
18	,, ,, Top (2nd Ex.)	559	160	—	—	—	—	—
18	,, ,, Mid (2nd Ex.)	540	173	—	—	—	—	—
18	,, ,, Butt (2nd Ex.)	570	183	—	—	—	—	—
19	Kranji, Borneo	1029	371	10,920	—	—	—	—
20	Larch, Russian	646	157	4,203	2·875	2·672	2·174	2·663
21	Mahogany, Cuba	769	214	3,791	2·750	3·250	3·024	2·428
22	,, Honduras	659	201	2,998	2·806	2·750	3·044	2·820
23	,, Mexican	678	196	3,427	2·437	2·633	2·549	2·394
24	Molavé, Philippine Islands	1013	311	7,812	—	—	—	—
25	Mora, Trinidad	1087	332	9,240	...	3·812	—	—
26	Oak, Baltimore	747	181	3,832	...	2·630	—	—
27	,, English	735	194	7,571	3·562*	3·411*	3·225*	3·151*
27	,, ,, (2nd Ex.)	886	209	...	2·396†	2·110†	2·217†	2·064†
27	,, ,, (3rd Ex.)	862	121	3,837	—	—	—	—
28	,, French	976	219	8,102	...	3·547	—	—
28	,, ,, (2nd Ex.)	1082	208	—	—	—	—	—
29	,, Dantzic	835	118	4,212	3·773	3·375	3·166	3·062
30	,, Modena	1109	211	—	—	—	—	—
31	,, Sardinian	990	190	...	...	2·604	—	—

* Seasoned. † Unseasoned.

TABLE CLXIX.—(*Continued.*)

Number.	Name of Wood.	Specific gravity.	Breaking Weights used for—					
			Transverse strain on pieces 2″×2″×84″	Tensile strain on pieces 2″×2″×30″	Vertical strain on pieces—			
					1″×1″×1″	2″×2″×2″	3″×3″×3″	4″×4″×4″
			lbs. per sq. in.	lbs. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.	Tons. per sq. in.
32	Oak, Tuscan	1040	190	…	…	2·437	—	—
33	,, Spanish	1042	141	—	—	—	—	—
34	,, Rhenish	1026	165	—	—	—	—	—
35	,, White, American	983	201	7,021	3·166	3·109	2·500	2·060
36	Pine, Red, Canada	552	163	2,705	3·479	2·115	2·431	2·125
37	,, Yellow ,,	435	157	—	—	—	—	—
	,, ,, ,, (2nd Ex.)	551	121	—	—	—	—	—
	,, ,, ,, (3rd Ex.)	554	126	2,027	2·521	1·863	1·750	1·375
38	,, ,, Oregon	596	—	—	—	—	—	—
	,, Pitch, American	659	262	4,666	…	2·885	—	—
39	,, ,, 2nd Ex. Inner layers	708	222	—	—	—	—	—
	,, ,, 2nd Ex. Outer ,,	711	243	—	—	—	—	—
	,, ,, 3rd Ex. Inner ,,	528	183	—	—	—	—	—
	,, ,, 3rd Ex. Outer ,,	547	189	—	—	—	—	—
40	Sabicu, Cuba	917	331	5,558	3·082	3·961	4·140	3·922
41	Teak, Burmah	776	228	3,301	2·416	2·838	2·640	2·343
	,, ,, (2nd Ex.)	807	211	—	—	—	—	—
42	Tewart, Australia	1169	257	10,284	4·469	4·195	3·931	4·102
43	Pingow, Borneo	747	318	6,311	…	4·539	—	—
44	Pyengadu, Burmah	1176	324	9,656	…	5·208	—	—

TABLE CLXX.

Showing the woods which have been experimented upon, arranged in numerical order of transverse strength; calculated from the formula $\frac{lw}{4ad^2}=S$; the weight per cubic foot; the comparative transverse strength, English Oak being $=1{\cdot}000$; the elasticity per formula $\frac{l^3w}{16ad^3\delta}=E$; and the comparative elasticity, English Oak being $=1{\cdot}000$. Abstracted from the tables accompanying the description of the various kinds.

NAME OF THE WOOD.	Numerical order of transverse strength.	Weight per cubic foot.	Strength per formula, $\frac{lw}{4ad^2}$	Comparative transverse strength, English Oak being =1·000.	Deflection at the crisis of breaking in inches.	Elasticity per formula, $\frac{l^3w}{16ad^3\delta}$	Comparative elasticity, English Oak being =1·000.
		lbs.					
Kranji	1	64·31	3892	1·838	4·040	1,504910	3·484
Iron-bark	2	71·37	3695	1·745	3·812	960740	2·165
Greenheart	3	71·82	3498	1·652	4·625	436880	·982
Mora	4	67·94	3481	1·644	4·940	466570	1·051
Sabicu	5	67·31	3393	1·602	3·766	972350	2·186
Pyengadu	6	73·50	3342	1·578	4·250	1,031940	2·320
Pingow	7	46·25	3316	1·566	3·816	1,259690	2·832
Molavé	8	63·31	3264	1·541	5·166	823990	1·853
Kapor	9	59·75	3108	1·468	3·766	1,463000	3·290
African	10	62·06	2909	1·374	5·142	410430	·923
Tewart	11	73·06	2701	1·276	4·750	776990	1·747
Chow	12	69·75	2559	1·208	2·833	1,013836	2·280
Elm, Canada	13	46·75	2415	1·141	8·790	618550	1·391
Pine, Pitch	14	39·37	2348	1·109	...	755240	1·700
Teak, Moulmein	15	49·47	2303	1·088	5·930	530970	1·193
Fir, Dantzic	16	36·37	2301	1·087	5·142	579190	1·302
Kari, Australia	17	61·31	2264	1·069	6·060	930950	2·093
Ash, English	18	46·00	2263	1·069	8·625	573100	1·289

TABLE CLXX.—(*Continued.*)

NAME OF THE WOOD.	Numerical order of transverse strength.	Weight per cubic foot.	Strength per formula, $\frac{lw}{4ad^2}$	Comparative transverse strength, English Oak being =1·000.	Deflections at the crisis of breaking in inches.	Elasticity per formula, $\frac{l^3w}{16ad^3\delta}$	Comparative Elasticity, English Oak being =1·000.
		lbs.					
Mahogany, Cuba	19	48·06	2247	1·061	3·450	771030	1·734
Oak, French	20	64·31	2242	1·059	7·187	622720	1·400
,, Modena	21	69·31	2212	1·045	6·295	400420	·900
,, English	22	51·72	2117	1·000	6·286	444680	1·000
,, American White	23	61·44	2110	·997	8·833	528650	1·189
Mahogany, Honduras	24	41·19	2105	·994	4·058	492550	1·130
,, Mexican	25	42·37	2054	·970	3·925	846100	1·903
Oak, Sardinian	26	61·87	1990	·940	6·500	363450	·817
,, Tuscan	27	65·00	1989	·939	766·0	248950	·560
,, Baltimore	28	46·69	1897	·896	7·133	703230	1·581
Kauri, New Zealand	29	34·31	1889	·892	4·000	721380	1·622
Blue Gum, Australia	30	64·31	1869	·883	4·210	778300	1·750
Jarrah, Australia	31	63·12	1800	·850	4·710	296810	·667
Fir, Spruce, Canada	32	30·25	1759	·831	5·187	771800	1·735
Oak, Rhenish	33	64·12	1729	·816	6·716	276550	·622
Pine, Red, Canada	34	34·56	1715	·810	4·625	588900	1·324
Ash, American	35	30·00	1675	·791	7·375	343980	·773
Larch, Russian	36	40·37	1643	·776	4·330	649130	1·459
Fir, Riga	37	33·81	1575	·744	3·625	752420	1·692
Oak, Spanish	38	65·12	1474	·696	6·616	239190	·537
Cedar, Cuba	39	27·44	1470	·694	4·366	449710	1·011
Pine, Yellow, Canada	40	32·08	1409	·665	3·837	621050	1·396
Oak, Dantzic	41	52·19	1243	·587	6·458	189680	·427
Elm, English	42	34·87	1032	·487	5·291	250820	·564

TABLE CLXXI.

Showing the woods which have been experimented upon, arranged in numerical order of tensile strength, and the comparative tensile strength, English Oak being = 1·000. Abstracted from the tables accompanying the description of the various kinds.

NAME OF THE WOOD.	Numerical order of tensile strength.	Direct cohesion on 1 square inch.	Comparative strength, English Oak being = 1·000.	NAME OF THE WOOD.	Numerical order of tensile strength.	Direct cohesion on 1 square inch.	Comparative strength, English Oak being = 1·000.
		lbs.				lbs.	
Kranji	1	10,920	1·442	Ash, American	20	5,495	·725
Tewart	2	10,284	1·398	Elm, English	21	5,460	·721
Pyengadu	3	9,656	1·275	Pine, Pitch	22	4,666	·616
Mora	4	9,240	1·220	Kauri, New Zealand	23	4,543	·600
Elm, Canada	5	9,182	1·213	Oak, Dantzic	24	4,212	·556
Greenheart	6	8,820	1·165	Larch, Russian	25	4,203	·555
Iron-bark	7	8,377	1·106	Fir, Riga	26	4,051	·535
Oak, French	8	8,102	1·071	,, Spruce	27	3,934	·520
Molavé	9	7,812	1·032	Oak, Baltimore	28	3,832	·506
Oak, English	10	7,571	1·000	Mahogany, Cuba	29	3,791	·500
Chow	11	7,199	·951	Ash, English	30	3,780	·499
Kari	12	7,070	·934	Mahogany, Mexican	31	3,427	·451
African	13	7,052	·931	Teak, Moulmein	32	3,301	·436
Oak, White American	14	7,021	·927	Fir, Dantzic	33	3,231	·427
Kapor	15	6,790	·896	Mahogany, Honduras	34	2,998	·396
Hornbeam	16	6,405	·846	Jarrah	35	2,940	·388
Pingow	17	6,311	·832	Cedar, Cuba	36	2,870	·379
Blue Gum	18	6,048	·798	Red Pine, Canada	37	2,705	·357
Sabicu	19	5,558	·734	Yellow Pine, Canada	38	2,027	·267

TABLE CLXXII.

Showing the woods which have been experimented upon, arranged in numerical order of vertical strength, and the comparative vertical strength, English Oak being = 1·000, abstracted from the tables accompanying the description of the various kinds.

NAME OF THE WOOD.	Numerical order of vertical strength.	Vertical force required to crush 1 square inch of base.	Comparative strength, English Oak being = 1·000.	NAME OF THE WOOD.	Numerical order of vertical strength.	Vertical force required to crush 1 square inch of base.	Comparative strength, English Oak being = 1·000.
		lbs.				lbs.	
Greenheart	1	15,275	2·000	Blue Gum, Australia	19	6,995	·915
Chow	2	12,591	1·648	Ash, English	20	6,964	·912
Kapor	3	11,939	1·561	Oak, White American	21	6,964	·912
Pyengadu	4	11,665	1·527	Pine, Pitch, American	22	6,462	·847
Iron-bark	5	10,306	1·348	Teak, Moulmein	23	6,357	·832
African	6	10,244	1·341	Mahogany, Honduras	24	6,160	·806
Pingow	7	10,167	1·331	Larch, Russian	25	5,985	·783
Tewart	8	9,397	1·229	Mahogany, Mexican	26	5,898	·772
Elm, Canada	9	9,098	1·191	Oak, Baltimore	27	5,891	·771
Sabicu	10	8,873	1·161	Kauri, New Zealand	28	5,880	·769
Mora	11	8,539	1·117	Oak, Sardinian	29	5,833	·763
Hornbeam	12	8,312	1·087	Elm, English	30	5,784	·757
Oak, French	13	7,945	1·040	Ash, American	31	5,495	·719
,, English	14	7,641	1·000	Oak, Tuscan	32	5,459	·714
,, Dantzic	15	7,560	·990	Fir, Spruce	33	4,852	·635
Mahogany, Cuba	16	7,280	·953	Pine, Red, American	34	4,738	·620
Jarrah	17	7,164	·937	Fir, Riga	35	4,724	·618
Fir, Dantzic	18	7,105	·930	Cedar, Cuba	36	4,480	·586

TABLE CLXXIII.

Showing that in the conversion of 1,413,894 cubic feet of hewn or square timber (raw material), comprising the following descriptions, the average yield of converted material—*i.e.*, timber, plank, board, &c., &c.—per cubic foot was as stated against each species in column A; also that the average yield of slabs and sawdust, or difference between the cubic contents of the converted and the raw material was as stated in column B.

TIMBER.	A. Proportion of converted per one cubic foot of raw material.	B. Proportion of slabs and sawdust per one cubic foot of raw material.	TIMBER.	A. Proportion of converted per one cubic foot of raw material.	B. Proportion of slabs and sawdust per one cubic foot of raw material.
Oak, various :—			Mexican Mahogany	·721	·279
Italian	·649	·351	Cuba ,,	·634	·366
American, Baltimore	·648	·352	Honduras ,,	·596	·404
Sardinian	·646	·354	Cedar	·726	·274
American White	·641	·359	Teak	·660	·340
French	·527	·473	English Elm	·531	·469
English	·526	·474	Canada ,,	·687	·313
Spanish	·520	·480	Canada Yellow Pine	·705	·295
			Dantzic Fir	·700	·300
Substitutes for Oak, &c. :—			Riga Fir	·677	·323
Tewart	·681	·319	Canada Red Pine	·650	·350
Sabicu	·674	·326	American Pitch Pine	·640	·360
Greenheart	·605	·395	Russian Larch	·610	·390
Mora	·555	·445	Canada Spruce Deals	·796	·204
African	·519	·481	,, Yellow Pine Deals	·742	·258

"Well-squared timber," as understood in the trade, is nearly die square, and admits of little wane on the angles at any part of the log. The yield of this is about ·68 per cubic foot of raw material, as shown in the table against Tewart. Some woods, when exceedingly well squared, will often yield a little more; as Mexican Mahogany. Others again, which are imperfectly manufactured, yield considerably less per cubic foot; as African.

The figures against Oak, English, were obtained from the conversion of both "rough" and "sided," not square timber. Also the figures against Elm, English, were obtained from "rough," and not square timber.

The results given in the table were obtained from the conversion of timber for ship-building at Woolwich Dockyard. For civil architecture and engineering purposes the yield per cubic foot would probably be better, as there would be less waste in cutting to straight than to curved lines.

The advantage of the table will be manifest on trial, since, if the figures in column A, which stand against any one of the woods mentioned in the list, are used as divisors of the net quantity of converted timber material required for any purpose, the quantity of hewn or square timber, *i.e.*, raw material, which it is necessary to purchase to produce it, is readily found.

Example:—If 5,600 cubic feet of converted timber material (Dantzic Fir) are required, how much hewn or square timber will it be necessary to purchase to produce it?

In column A, against Dantzic Fir, is ·700; therefore $\frac{5600}{·700} = 8{,}000$ cubic feet.

Also, if the figures in column A are used as multipliers, the converted produce can be ascertained

approximately of any known quantity of raw material upon hand.

Example:—8,000 cubic feet of hewn or square timber (Dantzic Fir) is ∴ 8,000 × ·700 = 5,600 cubic feet of converted timber.

Also, if the figures in column B are used as multipliers with the hewn or square timber, the approximate waste in the conversion of it will be obtained.

Example:—Dantzic Fir, 8,000 × ·300 = 2,400 cubic feet waste in slabs and sawdust.

TABLE CLXXIV.

SHOWING THE USES OF THE PRINCIPAL WOODS DESCRIBED IN THIS WORK.

SPECIES.	WHERE GROWN.	USES.
Acle	Philippine Islds.	Naval and civil architecture.
Aki	New Zealand	Turnery, agricultural implements, clubs, and spears.
Alder	Britain	Carpentry, piles, packing cases, turnery.
Angélique	French Guiana	Suitable for constructive purposes in lieu of African, Mahogany, or Teak.
Angelim-vermetho	Brazil	Naval construction.
Annan	Burmah	Constructive purposes generally, gun carriages, &c.
Araribo-ou-potomuju	Brazil	Cabinet work, domestic arts.
Araribo-roza	,,	,, ,,
Ash, British	Britain	Coach and wheelwrights' work, agricultural implements, domestic arts, turnery.
,, Canadian	Canada	As Ash, British, boats' oars, &c.
,, American	North America	,, ,, boats' oars, best sort, &c.
Balata	Trinidad	A substitute for plain or inferior African or Mahogany.

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Balata . .	French Guiana .	A substitute for hard woods in architectural works, furniture, &c.
Beech . . .	Britain . .	Cabinet and chair making, piles, wedges, turnery.
Beefwood, or She Oak . .	Australia . .	Furniture, domestic arts.
Blackwood .	,, . .	Wheelwrights' and turners' work.
Blue Gum . .	,, . .	Architectural works, piles, fences, general purposes.
Boco . . .	French Guiana .	Constructive purposes, furniture, turnery.
Boxwood . .	Australia . .	Sheaves for pulleys, mallets, turnery, &c.
Camara . .	Brazil . .	Boat-building.
Camphor, or Kapor	Borneo . .	Planks, beams, piles, constructive purposes generally.
Canella-preta .	Brazil .	Constructive purposes generally.
Carapo . .	Trinidad . .	A substitute for plain and inferior Mahogany.
Cedar, Cuba, Mexican & Honduras	... ...	Cabinet work generally, cigar boxes, patterns, &c.
Cedar, Bermudian.	... ...	,, boat-building, &c.
,, Florida .	... ...	,, ,,
,, Pencil .	... ...	,, pencil making.
Celery-topped Pine	V. Diemen's Land	*See* Pine.
Chestnut . .	Britain . .	Carpenters', wheelwrights', and coachmakers' work, domestic arts, &c.
Chow . . .	Borneo . .	Planks, beams, piles, constructive purposes generally.
Ébène . . .	French Guiana .	Furniture, domestic arts, turnery.
,, rouge .	,,	,, ,,
,, verte . .	,,	,, ,,
Elm, Common .	Britain . .	Ships' keels, bilge planks, wheelwrights' and carpenters' work, carving and turnery.
,, Wych . .	,, . .	Do., specially adapted for boat-building.
,, Dutch .	,, . .	,, ,,
,, Canada Rock	Canada .	Ship-building, coach and wheelwrights' work, domestic arts, &c.
Emu . . .	Australia . .	Turners' work.
Fir, Dantzic .	Prussia . .	Constructive purposes generally, deck deals, masts, &c.
,, Eliasberg .	North Europe .	,, ,, cabinet work.
,, Saldowitz .	,, .	,, ,, ,,

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Fir, white wood	North Europe	Common purposes in carpentry, packing cases, &c.
,, Riga	Russia	Constructive purposes generally, superior for masts.
,, Swedish	Sweden	Constructive purposes generally, inferior to Dantzic or Riga.
,, Norway	Norway	,, ,,
,, Spruce	N. Europe and N. America	Light framing, floor boards, boats' oars and spars, scaffold poles, &c.
Forest light wood	Australia	Cabinet work.
Greenheart	Demerara	Keelsons, shelf pieces, and planking in ships, excellent for piles, &c.
Grignon	French Guiana	Civil architecture, domestic arts.
Grapiapunha	Brazil	Naval and civil architecture.
Guarabu	,,	,, ,,
Gum, White	Australia	Constructive purposes in carpentry.
,, Brown	,,	,, ,,
,, Curly	,,	,, ,,
,, Red	,,	,, ,,
,, Swamp	,,	,, ,,
Hackmatack	North America	*See* Larch, American.
Honeysuckle	Australia	Furniture work, boat-building.
Hornbeam	Britain	Cogs in machinery, wheelwrights' work, turnery, &c.
Incaranda-tan	Brazil	Furniture and ornamental work.
,, cabiuna	,,	,, ,,
Iron-bark	Australia	Ship-building, piles, agricultural implements, fencing, &c.
Iron-wood	Burmah	*See* Pyengadu.
Jarrah	Australia	Ship-building, piles, railway sleepers, agricultural implements.
Jenipapo	Brazil	Carpentry, domestic arts.
Juba	Havana	A substitute for Sabicu, in ship-building, furniture, &c.
Kahikatea	New Zealand	Indoor work in houses, packing-cases, &c.
Kahikatoa	,,	Architectural works, piles, domestic arts, &c.
Kammone	Burmah	Constructive purposes generally.
Kamonpew	,,	,, ,,
Kapor	Borneo	*See* Camphor.
Karra	Philippine Islds.	Constructive purposes generally.
Kari	West Australia	Piles, railway sleepers, agricultural implements, &c.

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Kaurie or Cowdie.	New Zealand .	*See* Pine.
Kathitka . .	Burmah . .	A substitute for Mahogany.
Kiwideah . .	New Zealand .	Wheelwrights' work, agricultural implements.
Kohekohe . .	,, .	A substitute for Cedar, cabinet work, domestic arts.
Kowai . . .	,, .	Turnery, agricultural implements, clubs and spears.
Kranji . . .	Borneo . .	Planks, beams, piles, constructive purposes generally.
Larch, Italian .	Europe . .	All kinds of frame-work in architecture, piles, &c.
,, Polish .	,, . .	,, ,,
,, Russian .	,, . .	,, ,,
,, American .	North America .	,, ,, and ship-building.
Lignum Vitæ .	West Indies, &c.	Sheaves for pulleys, turnery, domestic arts, &c.
Lauan . . .	Philippine Islds.	Naval and civil architecture, furniture, &c.
Maconatari . .	French Guiana .	A furniture wood, &c.
Macaranduba .	Brazil . .	Employed in ship-building.
Mahogany, Spanish	Cuba . .	Cabinet work, turnery, domestic arts, ship-building.
,, Honduras	... ...	,, ,,
,, Mexican.	... ...	,, ,,
,, Nassau .	... ...	Cabinet work, turnery, domestic arts.
,, St. Domingo	... ...	,, ,,
Malatapay . .	Philippine Islds.	Constructive purposes generally.
Mambog . .	,, .	,, ,,
Mangachapuy .	,, .	,, ,,
Mapilia . .	,, .	,, ,,
Mangalo . .	Borneo . .	Naval and civil architecture.
Matteral . .	Zambesi . .	Substitute for Mahogany.
Matai . . .	New Zealand .	Constructive purposes generally, furniture.
Meriquitiara. .	Brazil . .	,, ,,
Mida . . .	New Zealand .	Agricultural implements, clubs, spears, &c.
Miro . . .	,, .	Cabinet work, turnery, civil architecture.
Mocasso-cassa .	Zambesi . .	Constructive purposes generally.
Mocua . . .	,,	Ship and boat building, a crooked wood for knees.
Mocunca . .	,, .	,, ,,
Mocundo-cundo .	,, .	Constructive purposes generally, masts.
Molavé . .	Philippine Islds.	Cabinet work, ship-building.

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Monangare	Zambesi	Wheelwrights' and block makers' work, furniture.
Morrunda	,,	Ship and boat building,
Mora	Trinidad	Cabinet work, ship-building, piles, &c.
Mugunda	Zambesi	Ship and boat building.
Mussangara	,,	,, ,,
Musk	Australia	Furniture, and turners' work.
Myrtle, scented	,,	Carpenters' & wheelwrights' work.
,, Red	,,	,, ,,
,, White	,,	,, ,,
,, Yellow	,,	,, ,,
,, Brown	,,	,, ,,
Oak, African	... ...	Ship-building, carpentry, cabinet work, turnery, &c.
,, British	... ...	All kinds of constructive work, naval, civil, and military engineering.
,, Belgian	... ...	,, ,,
,, French	... ...	,, ,,
,, Piedmont	... ...	,, ,,
,, Turkey	... ...	,, ,,
,, American white	... ...	,, ,,
,, Italian	... ...	Similar to British, but not so generally useful.
,, Dutch	... ...	,, ,,
,, Dantzic	... ...	Deck and outside planks for ships, cabinet work, domestic arts.
,, Riga	... ...	Cabinet wainscot work, domestic arts.
,, Spanish	... ...	Constructive purposes of the second class.
,, Live	North America	Ship-building, sills to window and door frames, mallets, &c.
,, Swamp white	,,	,, ,,
,, Rough or post	,,	,, ,,
,, Black	,,	,, ,,
,, Scarlet	,,	,, ,,
,, Baltimore	,,	Cabinet and church furniture, general purposes.
,, Canadian	,,	,, ,,
Oregon or Douglas	,,	*See* Pine.
Pacouri-soufri	French Guiana	Furniture wood, domestic arts.
Padouk	Burmah	Constructive purposes generally, piles, &c.
Palo Maria	Philippine Islds.	,, ,,

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Panacoco	French Guiana	A strong wood for constructive purposes, furniture, &c.
Pangira	Zambesi	For ship and house building.
Pao-preta	,,	Cabinet work, turnery, &c.
,, ferra	,,	A ship-building wood, also for furniture.
,, ferro	,,	A substitute for Sabicu.
,, fava	,,	,, Mahogany.
Pao-de-pezo	Brazil	,, Lignum Vitæ.
,, setim	,,	Generally in the domestic arts.
Parewah	Burmah	Constructive purposes generally, piles, &c.
Penthityah	,,	,, ,,
Peguy	Brazil	Ship-building, carpentry, &c.
Peppermint, brown	Australia	Constructive purposes generally, charcoal, &c.
,, white	,,	,, ,,
Peroba-pardu	Brazil	Ship-building.
,, branca	,,	,, furniture, domestic arts.
,, vermetho	,,	A substitute for Cedar or Mahogany.
Pine, Red	Canada	Constructive purposes generally, masts, &c.
,, Yellow	,,	Cabinet and joiners' work, fittings, patterns, masts, &c.
,, Pitch	North America	Cabinet and joiners' work, outside planks for ships, masts, &c.
,, Oregon	West Coast of N. America	Constructive purposes generally, masts, &c.
,, Kaurie	New Zealand	Cabinet and joiners' work, fittings, patterns, masts, &c.
,, celery-topped	V. Diemen'sLand	Constructive purposes in carpentry.
Pingow	Borneo	Planks, beams, piles, constructive purposes generally.
Pingue	Zambesi	A substitute for Lignum Vitæ.
Pink wood	Australia	Constructive purposes, cabinet work.
Piquea-marfim	Brazil	Cabinet work, a substitute for satin wood.
Plum tree	Australia	Furniture, gun stocks, &c.
Pohutukawa	New Zealand	Ships' frames, carpentry, agricultural implements.
Puriri	,,	,, ,,
Pugatea	,,	Civil architecture, domestic arts.
Pyengadu	Burmah	Constructive purposes generally, piles, &c.
Raiz-de-Pingue	Zambesi	*See* Pao-preto.

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Rata	New Zealand	Cabinet work, naval and civil architecture.
Rewarewa	,,	,, carpentry, piles, shingles, &c.
Rimu	,,	,, civil architecture.
Rosewood	Brazil	Cabinet and pianoforte makers, domestic arts, turnery.
Rose, male	French Guiana	A furniture wood, useful in domestic arts.
,, female	,,	,, ,,
Sabicu	Cuba	Cabinet work, ship-building, domestic arts, turnery.
Santa Maria	Central America	,, ,,
Sassafras	Australia	Carpenters' and cabinet work, domestic arts, &c.
Satiné	French Guiana	Naval and civil architecture, cabinet work, turnery.
Securipa	Brazils	Constructive purposes generally.
She Oak	Australia	*See* Beefwood.
Simorouba	French Guiana	A furniture wood, useful in domestic arts.
St. Martin	,,	Naval and civil architecture, cabinet work, turnery.
Stinkwood	Australia	Cabinet work, domestic arts.
Stringy bark	,,	Constructive purposes in carpentry, piles, fences, domestic arts.
Tanakaha	New Zealand	Constructive purposes generally, masts, &c.
Tarata	,,	Agricultural implements, domestic arts.
Tawa	,,	Carpenters' and wheelwrights' work.
Tawada	,,	Cabinet work, turnery.
Tapinhonho	Brazils	Ship-building.
Teak, Burmah ,, Malabar ,, Siam	... ...	Applicable to all kinds of naval, civil, and military engineering, cabinet and carpenters' work.
Tepow	New Zealand	Carpentry and wheelwrights' work.
Tewart	Australia	Ship-building, piles, civil architecture.
Thingan	Burmah	Constructive purposes generally.
Thitkado or Toon	,,	Substitute for Cedar or Mahogany for furniture purposes.
Thitka or Kathitka	,,	,, ,,
Tongiho	New Zealand	Boat-building, carpentry, &c.
Toraira	,,	Carpenters' and wheelwrights' work.

TABLE CLXXIV.—*continued.*

SPECIES.	WHERE GROWN.	USES.
Totara . .	New Zealand .	Cabinet work, ship-building, substitute for Mahogany in domestic arts.
Towai . . .	,, .	Constructive purposes generally.
Vinhatico . .	Brazils . .	A substitute for Cedar.
Violet . . .	French Guiana .	Much prized by cabinet-makers, turners, &c.
Wacapou . .	French Guiana .	Substitute for Rosewood for furniture, &c.
,, gris .	,, .	,, ,,
Wattle, Black .	Australia . .	Agricultural implements, boats' oars.
,, Prickly .	,, . .	,, ,,
,, Silver .	,, . .	,, ,,
Wawaku . .	New Zealand .	Carpentry, wheelwrights' work.

THE END.

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